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Review Article

Fabrication of Textiles with Neem Extract and its Antimicrobial Application

Ibrahim H Mondal[1]*, Ashadur Rahman[2], Joykrisna Saha[3], Monirul Islam[1] and Rezowan Sakif[2]

[1]*Polymer and Textile Research Lab, Department of Applied Chemistry and Chemical Engineering, University of Rajshahi, Bangladesh*

[2]*Pabna Textile Engineering College, Pabna, Dhaka, Bangladesh.*

[3]*Mawlana Bhashani Science and Technology University, Santos, Tangail Dhaka, Bangladesh*

***Corresponding author:** Ibrahim H Mondal, Polymer and Textile Research Lab, Department of Applied Chemistry and Chemical Engineering, University of Rajshahi, Bangladesh

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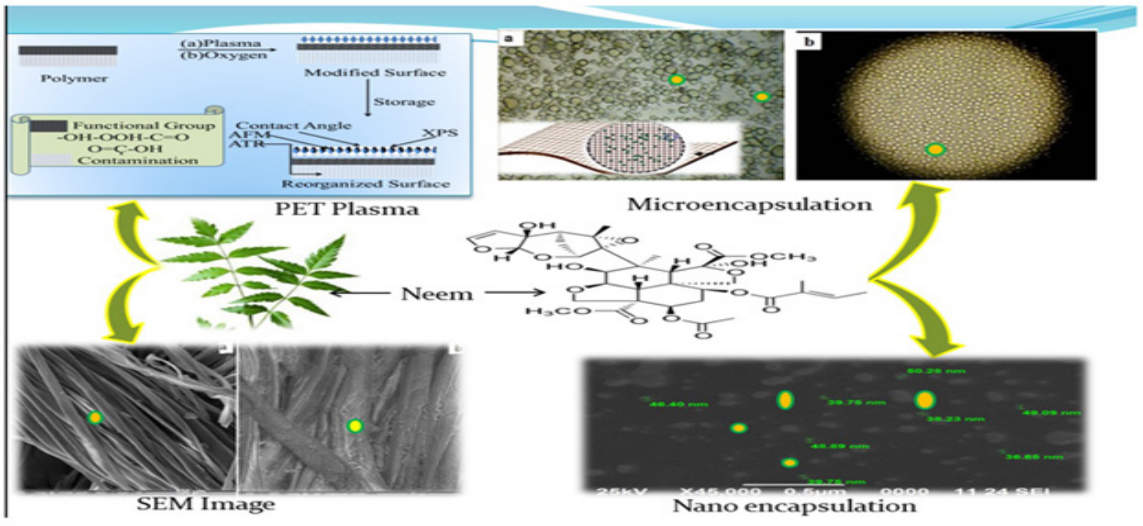
Abstract

This paper deals in an inclusive review of sustainable antimicrobial finish of textiles using natural products such as neem extract. Neem is a novel plant that contains versatile characteristics. Due to antimicrobial characteristics of neem is being it can be applied on textiles as finishing agent has achieved significant properties in new era. In this review, research, the antibacterial finish on textiles using the active natural ingredients of neem extracts that showed outstanding performance by using microencapsulation, nanocapsulation and different methods. Neem extract has been successfully integrated to the textile's substrate imparting a sustainable antibacterial antimicrobial activity against microbes. The outcomes exhibited that the treated fabrics inhibited the growth of bacteria by more than 90% as compared to the raw sample in case of several washing. There are many chemical ingredients which are used on textiles as antimicrobial finishes are unhygienic and toxic for the environment. In recent science, recently people have become more conscious about the hygienic textiles due to its ecofriendly demand. Around the world, especially in the Indian subcontinent, the neem trees are available for antimicrobial uses in cheap and healthy. The natural antimicrobial plant of neem consists of many components especially nimbidin that are mostly effective on textiles for safely antimicrobial issues. It also contains antioxidant, antimicrobial, antifungal and many more potential elements that increase the zone of inhibition of the material against microbes as producing antimicrobial resistant fabric. During this review we will focus on the sustainable use of neem as an antimicrobial finish on textiles (Graphical Abstract).



Graphical Abstract (1, 28, 30, 33, 34)

Keywords: Neem; Antimicrobial; Sustainable Finish; Natural Textiles; Technical Textile

Introduction

Natural antimicrobial finished fabric is essential crying need for nowadays. Hopefully, it is increasing the demands of ecofriendly products in last decade gradually. Customers are trying to find better comfort in fresh and odour free clothing for the betterment of a healthy life. Therefore, many antibacterial agents are applied to fabricate antibacterial textiles, like neem, quaternary ammonium compounds [1]. Antimicrobial finishing may be a chemical and natural that's accustomed to destroying or inhibiting the expansion of microscopic organisms. There are two different functions that antimicrobial protection provides in textiles [2,3]. The primary is the protection of the wearer against pathogens or odor-generating microorganisms. The other is that the protection of the textile from decays caused by mold, mildew, microorganisms [4]. Humid conditions and warm temperatures establish a desirable environment for the expansion of bacteria, fungi, and molds. Unfortunately, Textiles are a super media for the expansion of microorganisms, especially when nutrients and moisture are present. Their large area is additionally a key factor that permits a substantial amount of microorganisms to grow on fabric [5]. Furthermore, in medical textiles, antimicrobial finishes aim to prevent the cross-contamination of pathogenic microorganisms [5] and inhibit the spread of communicable disease through contaminated clothing [6].

Antimicrobial treated textile makes it easy to prevent any modification of visual appearance and any microbes like pathogenic and odour creating purpose [6-11]. The plant of neem consists of many components which are mostly effective on textiles for antibacterial, antifungal and also on. Some components are to blame for antimicrobial activity which showed in numerous research like these nimbolide, nimbidin, mahmoodin, margolone, margolonone and isomargolonone of these components mostly effective and excellent leads to one purpose like antibacterial [6]. The chemical structure of neem is shown in Figure 1 below. Neem oil is the most effective textile substrate for antimicrobial finishing [12]. During plasma treatment, the fabric has modified in the surface. The fabric has been changed morphologically and chemically. The essential temperature is required at lower than other methods. Plasma treatment is a sustainable method due to several washing [8-10]. Nanoparticles (NPs) are deliberated as elements having a small size which are less than 100 nm in at least one of three favorable sizes as though the antimicrobial element penetrate to fabric easily [13].

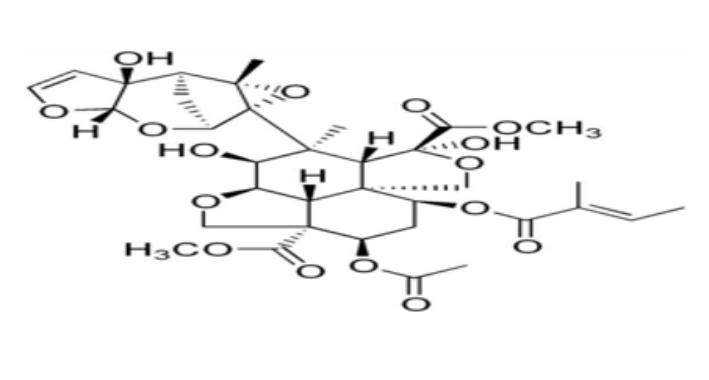


Figure 1: Chemical Structure of neem (Azadirachtin indica) [7].

In Nano encapsulation treatment on textile, to achieve the better results in sustainable antimicrobial finishing on textile substrates. The active antimicrobial agent applied on textiles at a slow process control release that is long lasting durability in several laundering process [14,15]. In microencapsulation treatment, this technique implies coating on textile substrates which is durable than other processes and particles size is less than 100 nm. As a result, the finishing process is durable due to several times washing [16]. Antibacterial finishes are highly recommended for hygienic textiles to prevent infection. Antimicrobial finishing of neem treated textile is very essential for bioactive uses. Though eco-friendly & cheap, the usage of natural ingredients of neem on textile finishing has not increased due to its venerable washing durability. But good results can be obtained where the effectiveness remains same after multiple washes by using some specialized techniques through the application of extracts from neem on textiles. Micro-encapsulation and plasma treatments are the specialized techniques that are used for maximizing the sustainability of antimicrobial finish. In this review, paper affectivity Activity of Antimicrobial finish & sustainability of the finishing is described in detail. In future more work will be done on different sustainable and bioactive medical uses of neem on textiles [17].

Antimicrobial Efficacy of Neem and Sustainability

The extracts of medicinal plants neem(A. indica) are tested for the functional finishing of textile materials [18-20]. Tree commonly referred to as Neem, belongs to Meliaceae family commonly seen in South Asia, is established as a standard antibiotic for a broad spectrum bacterial pathogens. Neem leaf extracts contain organic compounds like nimbidin, nimbolide, mahmoodin, margolone, margolonone,andisomargolonon, all of which show good antibiotic properties [21]. Satyavatiet et al. the natural antibacterial agents

like neem are mostly effective on surrounding application area of the material surface. The appliance of neem on textile substrate by pad dry method noticed that no visible growth of bacteria at the periphery of the applying area. As a result, it induced the zone of inhibition of the neem treated area also 14mm and 20mm against the E. coli and S. aureus respectively. The antimicrobial efficacy and therefore the zone of inhibition area of the fabrics showed the outcome for the combined formation of neem and chitosan extract solution. Moreover, the zone of inhibition and antimicrobial efficacy on the upwards surrounding area of the fabrics enhanced so as to mix formation of neem chitosan extract solution, neem chitosan composite, and neem chitosan nanoparticles respectively. This experiment was assessed by using AATCC-147 [22]. Neem comprises an unlimited amount of bioactive components that are mostly effective on textiles substrate for his or her special attribute. Neem consists in an exceedingly huge amount of antimicrobial properties that are active against any microbes on surrounding space of cloth upwards. Sairam et al observed different components of neem in numerous clinical research with a view to sourcing the antimicrobial efficacy of neem leaves [23]. In ANOVA study, it found the outstanding results for antimicrobial activity to of various neem and chitosan extract solution that the antimicrobial of neem was higher than the chitosan. The variation between them was 73. 13 which indicated the activity of antimicrobial effects on fabric upwards against E. coli and S. aureus bacteria. It found the wonderful antimicrobial activity on the periphery of application area of material to the various combination of neem chitosan extract, neem chitosan composite and neem chitosan nanoparticles for various concentration of solution [24].

They noticed that the bacterial reduction rate enhanced because of using herbal antimicrobial agents like neem against E. coli and S. aureus bacteria but it couldn't find proper results on fabric surface for using other antimicrobial agents rather than herbal antimicrobial agents. This experimental methodology is conducted by AATCC 100 standards [24]. Chopra et al. observed the microbe's reduction rate against E. coli and S. aureus bacteria by using the pad dry method. They were used herbal antimicrobial agent like neem that showed 100% and 93% reduction rate for S. aureus and E. coli respectively on the contrary, the mix of neem chitosan composite applied on fabric that diminished the bacteria S. aureus 98% and E. coli 89.1% for big volume production while neem chitosan extract solution reduced bacteria for S. aureus 92% and 87% correspondingly bacterial reduction rate for E. coli 86.9% and 83.5% respectively [25]. Chung et al. assessed antimicrobial activity of neem leafs and chitosan extracts. They observed the higher and sustainable antimicrobial effects on fabric surface [26]. It is well-known that polyester fabric may be hydrophobic in nature. In normal temperature and pressure, polyester fabric cannot absorb water easily. Additionally any natural treatment like neem application on polyester surface is much more difficult. For this problem, Plasma treatment conducted by any gas like oxygen is important before applying antimicrobial treatment on fabrics. In below the Figure 2 indicates the crystalline nature of materials that showed high peck and high intensity in graph [27].

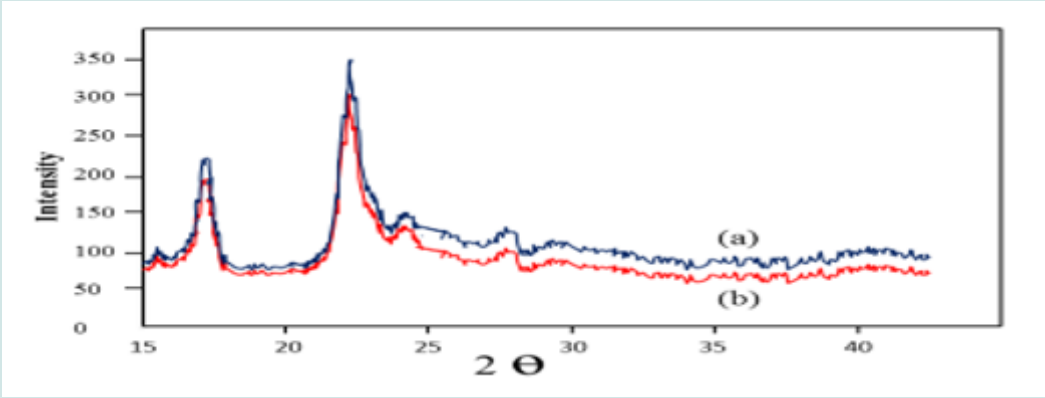


Figure 2: X-ray deffractogram in (a) untreated and (b) Treated Fabric by Plasma treatment [17].

When the fabric was absorbed liquid highly considering at increasing time, the fabric would be shown recognitions to higher

a. Bacteria reduction and

b. zone of inhibition respectively in below Figure 3 [27].

By using oxygen plasma, oxidization was performed in the reaction treatment zone. As a result, the acid was formed which contained a chemical group that would be increased the polarity of the PET fabric. Furthermore, antimicrobial activity and bacterial reduction rate also increased due to increase the absorbency of the PET fabric. These treatment conducted by azadirachtin were extracted from neem fruits in Figure 4 [27]. Besides, in below fig. 4 shows reduced contact angle, the material prepared for absorption. Achieving betterment in absorbency of PET fabric, it required to perform chemical modification of material like hydrolysis and plasma treatment before using neem extract for penetration of water on fabric surface. After the next process seed extract neemazal is applied on PET fabric to attain the most effective performance of antimicrobial fabric with or without cross-linking agent just in case of several washing [28-30]. PET Fabric surface

hydrolyzed with 20% NaOH for preparing hydrophilic to achieve 94% antimicrobial activity so as to use 10% seed extract against S. aureus. Antimicrobial activity of polyester fabric exhibited excellent properties just in case of washing. The quantity of seed extracts which was 10% of total solution that was applied on hydrolysis PET fabric to observe the antimicrobial activity against B. subtilis and P. vulgaris. It was assessed that the antimicrobial activity was 89% and 32% just in case of first washing. The PET treated fabric would show good antimicrobial properties against P. vulgaris. The durability of PET fabric showed 55% antimicrobial activity just in case of first wash [30].

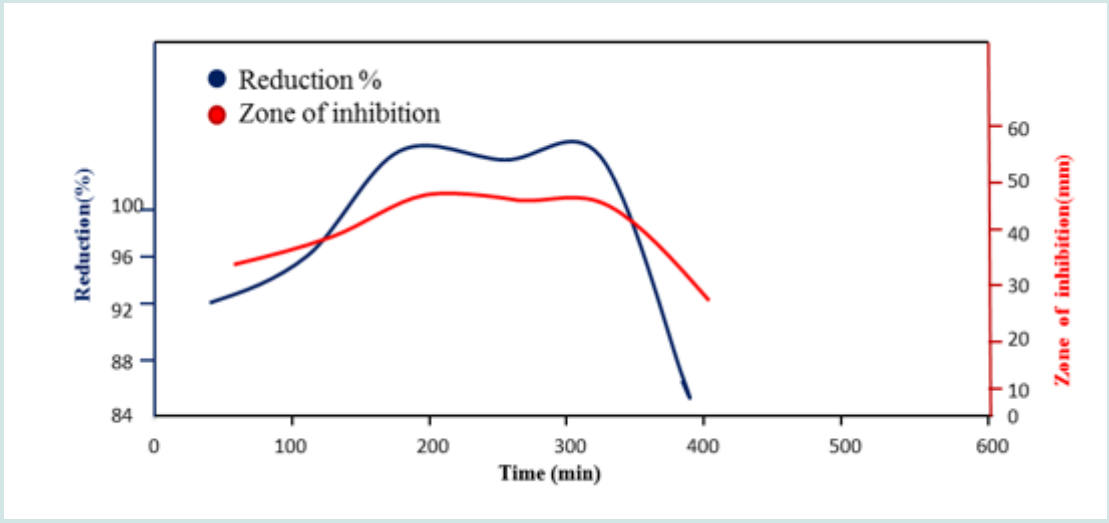


Figure 3: (a) Bacteria reduction and (b) zone of inhibition [28].

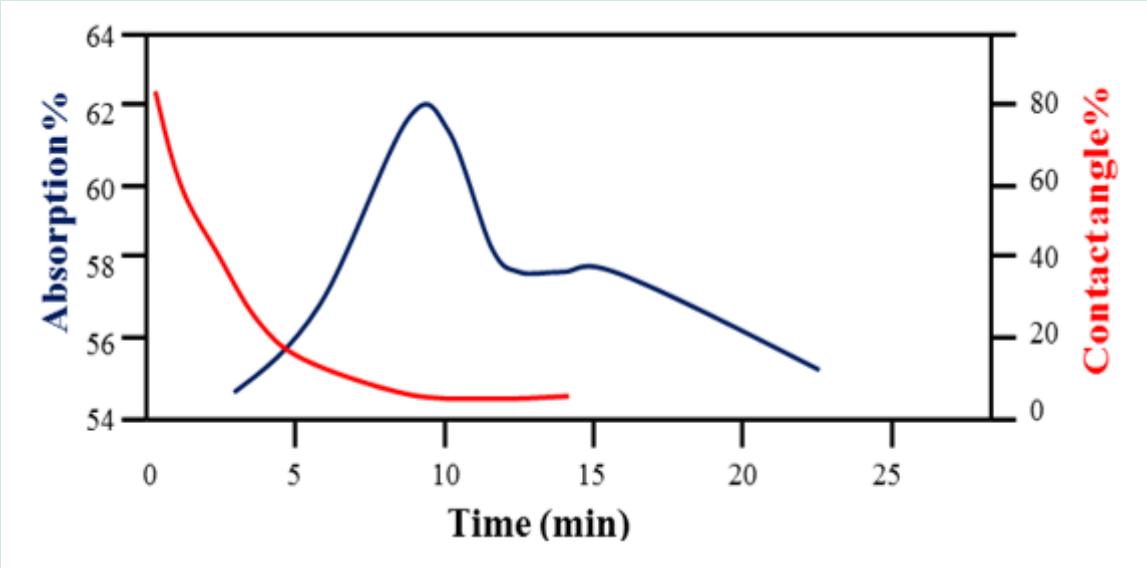


Figure 4: Absorption Vs. contact angle [28,29].

In plasma treatment, the fabric was prepared to better absorbency in which the fabric surface would be modified and increased the surface energy. As though, the surface energy was increased from 49.5 dyne/cm to 66.5 dyne/cm. It had fully been required low time to penetrate the drop of water like neemazal solution. The fabric surface was modified into rough surface. The fabric was increased the hydrophilic in nature that appearance in Figure 5. After plasma treatment, antimicrobial activity of polyester fabric was found to have excellent properties without washing against gram positive and gram negative bacteria. The antimicrobial activity for S. aureus was 96% and for B. subtilis was 94% without washing by the treating seed extract. The durability of antimicrobial activity of plasma treated PET fabric was reduced after washing several times. The fabric had been found that for first wash durability of S. aureus 86% and for B. subtilis was 61% in order to decrease gradually washing [28]. Antimicrobial activity of cotton fabric

treated with neem extracts which showed the bacterial reduction for S. aureus 100% and E. coli 78.44% whereas microencapsulation treated fabric with neem extracts showed bacterial reduction for S. aureus 93.45% and E. coli 55.21% respectively. In these results it is assessed that the sole neem extract applied on cotton fabric showed higher bacterial reduction percentage than the microencapsulated neem extract in Figure 6 [29].

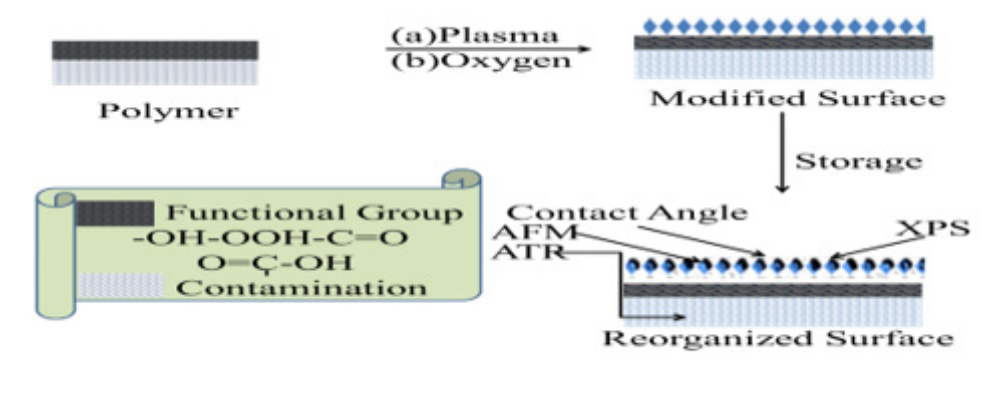


Figure 5: Plasma induced surface changes in polyester films [28].

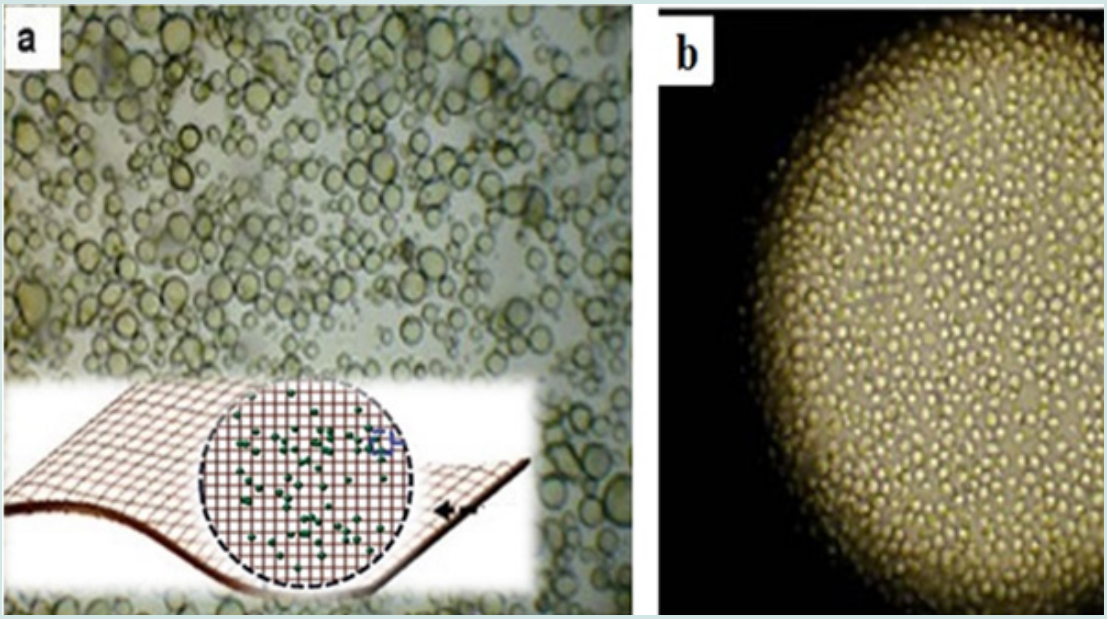


Figure 6: (a) Microencapsulated treated and fabric surface (b) only neem treated fabric surface [30].

Durability of only neem extract(without cross-linking) after 15 times wash was retained no antimicrobial activity on fabric whereas microencapsulated neem treated on fabric after 15 times washing showed antimicrobial activity was 78% because thanks to microencapsulation with neem was formed bond formation with fabric. Durability of antimicrobial activity of neem treated microencapsulation on fabric had longevity that was retained on fabric than other treatment because of formation of chemical bond with fabric [30]. Anitha et al. assessed to extend the antimicrobial activity on textiles with higher absorbency. So far, DC air plasma treatment is one among others treatment to increase the absorbency of the fabric. However, DC plasma treatment was applied on cotton fabric. It increased the capillarity and porosity of the material absolutely. In Figure 7 showed (a) no changed that was untreated, (b) treated with DC plasma that modified info rough surface in the above corner of picture (b) which was suitable for higher antimicrobial activity against S. aureus and E. coli. Besides, The fabric found clearly the zone of inhibition for S. aureus (.5) mm and for E. Coli (0) mm in bacterial reduction respectively(c) neem oil vapour treated fabric that was created smoothly surface that was not sustainable for higher antimicrobial activity [31]. In Figure 8 represents the dimensions of nanoparticles that showed the ranges 50-70 nm and the fabric modified into rough surface which noticed higher area of fabric surface treated that increased the fabric absorbency. Furthermore, it showed antimicrobial activity of neem extract treated on cotton fabric and bacterial

reduction rate against for S. aureus 98.73% and for E. coli 86.84% whereas nanoparticles of neem extract treated bacterial reduction for S. aureus 100% and for E. coli 91.48%. But, after several time washing, antimicrobial activity reduced gradually. After 15 times washing showed no antimicrobial activity of neem extract against S. aureus and E. coli. But nanoparticles of neem extract treated cotton fabric which showed antimicrobial activity for S. aureus 66% and for E. coli 61% respectively after 15 times washing [31].

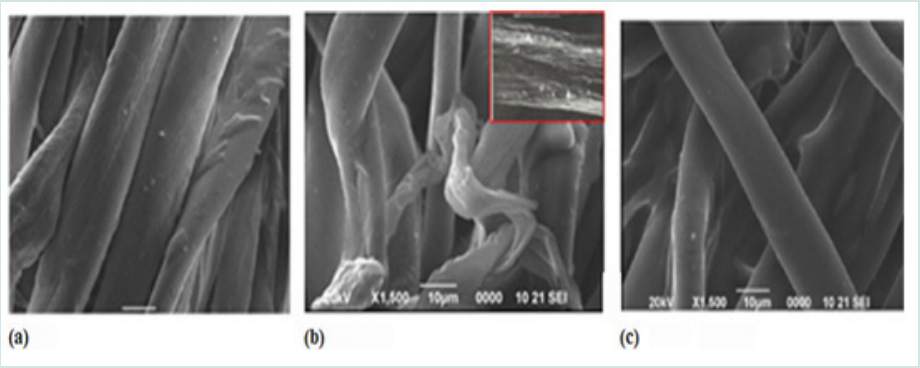


Figure 7: (a) SEM images of an untreated cotton fabric, (b) DC air plasma treated cotton fabric and (c)neem oil vapour treated cotton fabric [32].

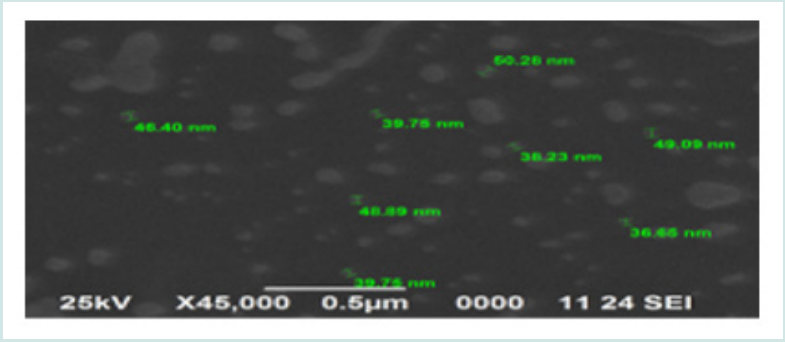


Figure 8: SEM images of nanoparticles on cotton fabric [33].

The SEM images exhibited clearly the antimicrobial activity and the zone of inhibition of neem and chitosan coated combination on cotton fabric. The fabric showed excellent zone of inhibition against the microorganism of gram positive (S. pyogenes) 15 mm and gram negative 16 mm (K. aerogenes) round the treated extent in Figure 9 [32]. Wool fabric is treated with neem extract which showed outstanding bacterial reduction rate just in case of several washing. Because of enzymatic scouring of wool fabric it showed high absorbency. The bacterial reduction was increased so as to add on extra percentage of neem solution. So that, the bacterial reduction was increased 90.75% and 95.02% respectively just in case of 3gram per Littre (gpl) and 5gpl neem extract solution used properly on wool fabric. Furthermore, it was retained bacterial reduction rate at 74.24% when applied 3 gpl neem extract on wool fabric just in case of 20 times washing for wool fabrics [33].

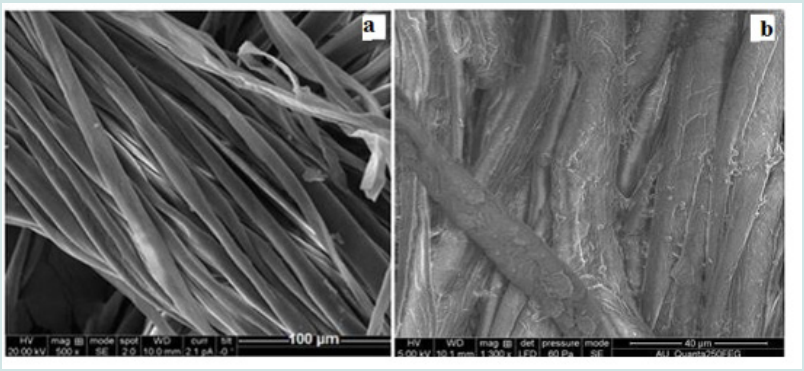


Figure 9: SEM images of (a) untreated and (b) treated cotton combined with [34].

Conclusion

The antimicrobial activity of neem and its combined applications have been shown in numerous textiles instances. It would vary because of the concentration of antimicrobial solution and application methods. Microencapsulation, nano particles and plasma treated on textiles showed excellent durability just in case of several washing. At present, Natural antimicrobial finished textiles could be a demandable product throughout the globe so as to comply with environmental concerns.

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