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Assessment of Eco-Friendly Natural Antimicrobial Textile Finish Extracted from Aloe Vera and Neem Plants

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Abstract

The aim of the present work was to assess an eco friendly natural antimicrobial textile finish extracted from Aloe gel and Neem plants. Extracted Aloe gel and active substance of Neem were mixed in a mordant to form a finish. Bleached cotton samples were treated with 5, 7, and 10% concentrations of Aloe gel and Neem separately. The same samples were then treated with a hybrid combination of Aloe gel and Neem (HCAN) extracts having 5, 7 and 10% concentrations. These finished samples were subjected to an antibacterial activity test against *E. coli* and *S. aureus*, an antifungal activity test against *Aspergillus Niger*, and a test of their durability of antibacterial finish fastness to washing by standard test methods. It was found that the hybrid combination of Aloe gel and Neem (HCAN) was an effective antibacterial and antifungal agent as compared to Aloe gel and Neem separately. It also showed good durability to washing.

Key words: eco friendly, anti microbial, natural textile finish, aloe vera extraction, neem extraction.

Introduction

Any operation (chemical or mechanical) for improving the appearance or usefulness of fabric is known as finishing. It can change a fabric's aesthetic and/or physical properties, as well as its texture and surface characteristics [1]. In various chemical finishes, antimicrobial finish has got great importance due to its relation with healthcare and medical textiles. Antimicrobial agents inhibit the growth or kills microbes to control their negative effect e.g. odour, staining and deterioration. Microbes are the tiniest of creatures, which cannot be seen by the naked eye. They consist of a variety of micro-organisms e.g. bacteria, fungi, algae and viruses etc. [2, 3]. There are various antimicrobial agents used as textiles finishes such as quaternary ammonium salts, chloro-ether phenols, poly(hexamethylene biguanidyne), silver and its compounds, organic-silicones, chitosan etc [4 - 8]. These agents can be classified on the basis of natural/synthetic, chemistry, the mechanism of antimicrobial activity, efficiency and washing resistance. Applications of natural antimicrobial agents have gained considerable attention in the field of medical and health care textiles due to properties such as being environment friendly, skin friendly, safe and non-toxic as compared to synthetic antimicrobial agents [9].

A variety of natural antimicrobial agents have been reported in literatures [9 - 11],

including polysaccharides and their derivatives e.g. chitosan, some plants extracts e.g. *aloe vera*, *neem*, *tulsi leaf*, *amla*, *clove*, *tea-tree oil*, *eucalyptus oil*, *datura stramonium*, *pongamia pinata*, *lantona camara*, *colotropis procera*, *ban-ajwain*, *grapefruit seeds* and *coptis chinensis roots (berberine)*, natural honey from munaka and chestnut, sericin derived from silkworm, natural dyes and pigments derived from plants, insects, animals and minerals [9 - 20]. These agents are rich chemically and contribute to controlling a variety of different diseases, infections and allergies. Among all these agents, plant extracts comprise a major segment. Aloe vera and neem plants are rich chemically and have traditional and pharmacological properties. Aloe vera leaf extracts consist of 75 nutrients and 200 active compounds, including 20 minerals, 18 amino acids and 12 vitamins. Neem extracts also have more than 300 active compounds e.g. azaadirachtin, salannin and nimbin etc. which have diverse medicinal activities [10, 11, 14, 15].

The aim of the present work is to assess the natural antimicrobial textile finish extracted from *aloe vera* and *neem* plants with respect to washing cycles. For this

purpose, *aloe gel* and *neem* extract finishes with different concentrations (5, 7, and 10%) and with a hybrid combination of both were applied on cotton samples for the assessment of antibacterial activity against *E. coli* and *S. aureus*, antifungal activity against *Aspergillus Niger* and the durability of antibacterial finish fastness to washing. To the best of the authors knowledge, the hybrid combination of aloe gel and neem is compared for the first time in this study.

Materials and methods:

Extraction of aloe gel

Aloe is processed within four hours of harvesting by using the hand fillet process. In this process, aloe gel was extracted by removing the outer layer of leaves and releasing the yellow sap, called latex (which contains aloin). The gel was further smashed for 90 min (in a machine) and then filtered to avoid any contamination.

Extraction of neem

Shadow dried 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

Table 1. Properties of extracted Aloe gel and Neem.

Extract	pH	Total solids dissolved, ppm	Salinity, ppt	Conductivity, $\mu\text{S/cm}$	Resistivity, $\Omega\cdot\text{cm}$
Aloe gel	4.5	636.0	0.15	540	$1.92\cdot 10^3$
Neem extract	4.5	835.0	0.19	414	$2.20\cdot 10^3$

Table 2. Nomenclature of samples.

Concentration of the ingredient	Abbreviation
5 % Aloe gel	AG-5
5 % Neem	NE-5
2.5% Aloe gel + 2.5 % Neem	HCAN-5
7 % Aloe gel	AG-7
7 % Neem	NE-7
3.5 % Aloe gel + 3.5 % Neem	HCAN-7
10 % Aloe gel	AG-10
10 % Neem	NE-10
5 % Aloe gel + 5 % Neem	HCAN-10

the large leaves and stem particles. The mixture was shelved for five days at room temperature to allow the active material to be dissolved in methanol. After five days, active substances of Neem were achieved.

Preparation of finish

The aloe gel and neem extracted were used as antimicrobial agents. These agents were mixed in acetic acid (100% conc.) at liquor ratio 10:1 to form a finish. Furthermore these finishes were filtered and tested using a multi parameter bench meter of HANNA instruments (USA). The results of measurement for aloe gel and neem are given in **Table 1**.

Application of finish

615 g/m² towel fabric was produced by using 60 tex ground yarn, 36 tex weft yarn, and 60 tex pile yarn at 25 ends/cm, 18 picks/cm and with an 11 mm pile height on the loom. Then bleached towel samples were treated with 5, 7 and 10% concentrations of the aloe gel (AG) and neem extract (NE) separately. The same samples were then treated with a hybrid combination of aloe gel and neem (HCAN) extracts of 5, 7 and 10% concentration (**Table 2**). The samples were finished on a Data Color Eco Exhaust Dyeing machine model 650, from Data Color (USA) at 80 °C while maintaining the pH at 5 for 30 minutes at a liquor ratio of 1:20. Then the samples were dried at 80 °C for 15 minutes in a tumble drying machine.

Assessment of finish

The finished samples were subjected to assessment of antibacterial activity by the AATCC 147-2004 method, antifungal activity by the AATCC 30-2004 method and the durability of antibacterial finish to washing by using a launder Ometer, model LEF from SDL Atlas (England).

Table 3. Zone of inhibition in mm against *E. Coli* and *S. aureus*.

Finish concentrations	Inhibition zone, mm	
	<i>E. coli</i>	<i>S. aureus</i>
AG-5	11	17
AG-7	12	18
AG-10	14	19
NE-5	11	18
NE-7	12	19
NE-10	14	20
HCAN-5	14	15
HCAN-7	15	16
HCAN-10	16	17

Table 4. Growth of *Aspergillus niger* in mm.

Finish concentration	Growth (mm)	
	2-Days	4-Days
Untreated	5	8
AG-5	4	5
AG-7	3	4
AG-10	2	3
NE-5	3	4
NE-7	2	3
NE-10	1	2
HCAN-5	2	3
HCAN-7	2	3
HCAN-10	1	2

Results and discussion

Cotton samples treated with 5, 7, and 10% concentrations of AG, NE and HCAN were subjected to antibacterial activity testing. The results were tabulated, as shown in **Table 3**.

It was observed from the above results that the circular inhibition zone increases with increasing concentrations of AG, NE and HCAN. Aloe gel contains multiple substances (anthraquinones, flavonoids, saponins, tannins and polysaccharides) that have antibacterial and antifungal activities. These substances have

the ability to bind adhesions, complex with cell wall, inactivate enzymes, denaturing proteins and disrupt the membrane to limit the growth of microbes by disabling cell functioning or reproduction [10]. The neem extract contains isoprenoids (diterpenoids, triterpenoids, limonoids and C-secomeliacins e.g. nimbin, salanin and azadirachtin) and non-isoprenoids, (amino acids, polysaccharides, polyphenolics e.g. flavonoids, dihydrochalcone, coumarin and tannins) [21 - 23]. The limonoids, azadirachtin (extract from leaves), flavonoids and tannins inhibit the growth of microbes by



Figure 1. Zone of inhibition against *E. coli* of samples A-10, N-10 and HCAN-10



Figure 2. Zone of inhibition against *S. aureus* of samples A-10, N-10 and HCAN-10

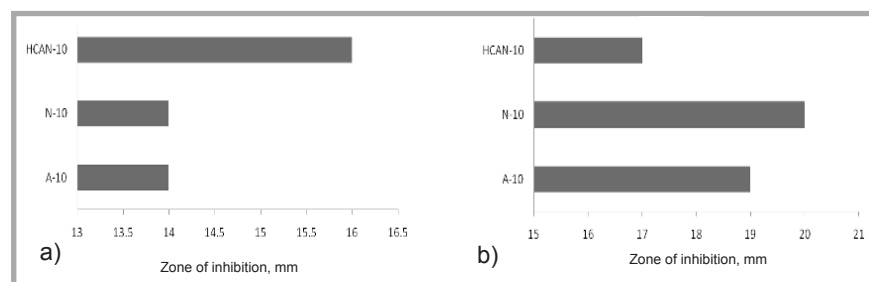


Figure 3. Antibacterial activity against; a) *E. coli* and b) *S. aureus*.

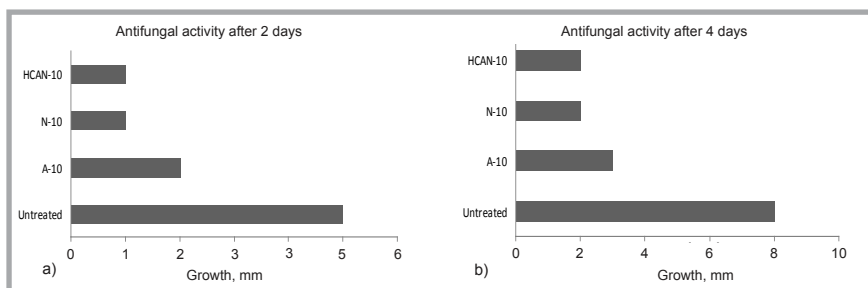


Figure 4. Antifungal activity against *Aspergillus niger*

Table 5. Zone of inhibition with respect to washing cycles.

Finish concentration	Inhibition zone of <i>E. coli</i> , mm				
	Un washed	5 washes	10 washes	15 washes	20 washes
AG-5	11	8	4	2	0
AG-7	12	9	5	3	0
AG-10	14	10	6	4	0
NE-5	11	8	5	2	0
NE-7	12	9	6	3	0
NE-10	14	10	7	4	1
HCAN-5	14	11	8	4	1
HCAN-7	15	12	9	5	2
HCAN-10	16	14	10	6	3



Figure 5. Zone of inhibition after 10 washing cycles of samples A-10, N-10 and HCAN-10.



Figure 6. Zone of inhibition after 20 wash cycles of samples A-10, N-10 and HCAN-10.

binding the adhesions and disrupting the cell wall membrane [10, 22]. Similarly HCAN is a hybrid combination of AG and NE. The mode of action of HCAN against microbes is the combined result of both AG and NE.

Furthermore, the zone of inhibition for *S. aureus* (Gram positive bacteria) was greater than for *E. coli* (Gram negative bacteria) at all concentrations of AG, NE and HCAN, which is because of the difference in the thickness of the cell wall of Gram positive bacteria (*S. aureus*) and Gram negative bacteria (*E. coli*). The thickness of the cell wall of Gram

positive bacteria is up to 80 nm or/and eight times higher as compared to Gram negative bacteria, which is only 10 nm. The zone of inhibition of A-10, N-10 and HCAN-10 samples against *S. aureus* and *E. Coli* is shown in Figures 1 and 2 (see page 121).

It was observed that the inhibition zone of HCAN treated samples was higher than aloe gel and neem treated samples against *S. aureus* as compared to *E. Coli*, as shown in Figure 3 (see page 121), which is also due to the difference in the cell wall thickness of microbes and the mode of action of aloe and neem.

Aloe gel disrupts the cell wall by using an electrochemical mode of action to penetrate and disrupt the cell wall [19]. On the other hand, neem extract (azadirachtin) not only interferes with the cell wall division during reproduction but also with protein synthesis as well [22]. It has more than one mode of action as compared to aloe gel.

Then cotton samples treated with 5, 7, and 10% concentrations of AG, NE and HCAN were also subjected to an antifungal activity test against *Aspergillus niger*; the results of which are tabulated in Table 4.

It was observed that the growth of *Aspergillus niger* in HCAN treated samples was less as compared to AG and NE treated samples after two and four days, as shown in Figure 4. It is reported that AG and NE both contain active substances that have antifungal properties. These substances inhibit the growth of enzyme (protease activity of dermatophytes) activity by inactivation [21]. It was also observed that *Aspergillus niger* growth was increased at all concentrations of AG, NE and HCAN after a specified period of time.

Finally different concentrations of AG, NE and HCAN treated samples were exposed to washing cycles (5, 10, 15 and 20) to measure the durability of the antibacterial finish to washing by using an AATCC launder-O-meter tester. The finished samples were washed with soap solution at 40 °C for 15 min. Then antimicrobial activity against *E. coli* was assessed, the results of which are tabulated in Table 5 and Figures 5 & 6.

It was observed that the zone of inhibition of *E. coli* diminished gradually as the number of washing cycles was increased for all concentrations of AG, NE and HCAN. HCAN shows greater durability to washing (up to 20 wash cycles) as compared to AG and NE separately, as shown in Figure 7. It was also observed that all fabric samples tested retained 50% activity up to 10 washing cycles, which was only owing to hydrogen bonds and weak van der Waals forces existing between the cellulose and antibacterial agent.

Conclusion

Natural antimicrobial agents: aloe gel (AG), neem extract (NE) and their hybrid

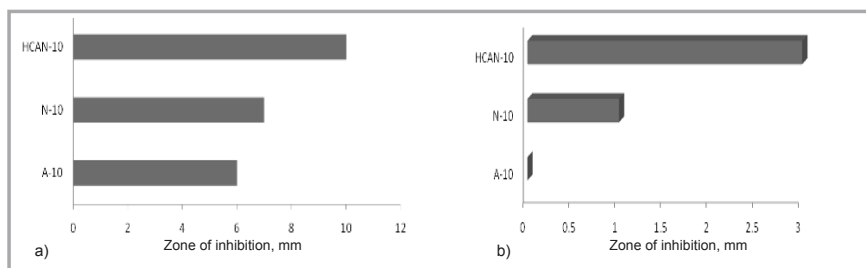


Figure 7. Durability of antibacterial finish to washes against *E. coli* after; a) 10 and b) 20 washes

combinations (HCAN) were applied on towel samples at 5, 7 and 10% concentrations in the presence of acetic acid. Then these finished samples were subjected to antibacterial activity testing against *E. coli* and *S. aureus*, antifungal activity testing against *Aspergillus niger* and assessment of the durability of the antibacterial finish to washing by standard test methods. The results revealed that AG, NE and HCAN have the ability to be used as antibacterial and antifungal agents. HCAN is more effective against *E. coli* and *Aspergillus niger*; but less so against *S. aureus* as compared to AG and NE. It also has greater durability to washing (up to 20 wash cycles) as compared to AG and NE. Hence it is concluded that HCAN has an effective natural antimicrobial and antifungal finish as well as greater washing fastness as compared to the AG and NE finishes individually.



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Director of the Institute: Danuta Ciechańska Ph.D., Eng.

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