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Development of anti-odour and super moisture absorbent socks

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ABSTRACT

The foot is among the heaviest producers of sweat in the body, as it is able to produce over 1 US pint (0.47 l) of perspiration per day. Socks help to absorb this sweat and draw it to areas where air can evaporate the perspiration. Although perspiration is odorless and 99% water, it provides a perfect medium for bacteria to grow. The bacteria cause foot odour. Foot odour is a type of body odour that affects the feet of humans and is generally considered to be an unpleasant smell. Wearing polyester or nylon socks may increase perspiration and therefore may intensify foot odor. In order to overcome this problem, a nylon sock was with increased moisture absorbency. The super absorbent solution was prepared by using various chemicals. Then the solution was examined for antibacterial activity by well diffusion method. The nylon socks were treated with this solution by dip dry method. The finished sample shows good moisture absorbency and also having antimicrobial activity when compared with the untreated sample by the testing method AATCC (147 and 30). It's having odor control property and also there is no any irritant reaction to contact with dermatitis by the testing method of organoleptic evaluation and Contact dermatitis testing. Ultimately, it is applicable for athletic persons and also common socks wearers.

Introduction

Clothing protects the human body from extreme weather and other features of the environment. It is worn for safety, comfort, and modesty and to reflect religious, cultural and social meaning. The practical function of clothing is to protect the human body from environmental hazards, such as weather (strong sunlight, extreme heat or cold, and precipitation, for example), insects, noxious chemicals, weapons, and contact with abrasive substances, and other hazards. Clothing protects the environment from the clothing wearer as well (Example: medical scrubs), referred by Meenakshi Rastogi (2009). A sock is an item of clothing worn on the feet. The foot is among the heaviest producers of sweat in the body, as it is able to produce over 1 US pint (0.47 l) of perspiration per day. Socks help to absorb this sweat and draw it to areas where air can evaporate the perspiration.

Ruth *et al.,* (1992) states that, the feet are among the three areas of the body that contains large sweat glands (the other two are the armpits and the palms of the hands). Feet wrapped in a layer of socks and socks for long periods become warm and perspire. Although perspiration is odorless and 99% water, it provides a perfect medium for bacteria to grow. The bacteria cause foot odor. Foot odor (or foot odour) is a type of body odor that affects the feet of humans and is generally considered to be an unpleasant smell. The main cause is foot sweat. Sweat itself is odorless, but it creates a beneficial environment for certain bacteria to grow and produce bad-smelling substances. These bacteria are naturally present on our skin as part of the human flora. Therefore, more smell is created with factors causing more sweating, such as wearing shoes and/or socks with inadequate air ventilation for many hours. Hair on the feet, especially on the toes, may contribute to the odor's intensity by adding increased surface area in which the bacteria can thrive. Given that socks directly contact the feet, their composition can have an impact on foot odor. Polyester and nylon are common materials used to make socks, but provide less ventilation than cotton or wool do when used for the same purpose. Wearing polyester or nylon socks may increase perspiration and therefore may intensify foot odor. *(http://www.epodiatry.com/smelly-foot.htm)*

Fibres used for manufacturing of socks

The ability for a sock to do its job in protecting the feet has a lot to do with its fiber composition. It is important to understand the characteristics of the fibers of a sock in order to pick one correctly. Hydrophobic fibers are those that repel moisture. Hydrophilic fibers are those that absorb moisture. Cotton fiber retains 3 times more moisture than acrylic. When exposed to ambient air, cotton retains moisture 10 times more than acrylic fibres. Hydrophilic rankings in descending order: cotton, wool, acrylic, and polypropylene.

Also important is the wicking gradient. Moisture from the feet can far exceed its absorption capacity. In order to minimize moisture accumulation on the skin's surface, the sock needs a wicking gradient to the shoe. A wicking gradient occurs when the shoe upper is breathable (nylon mesh) so that ambient air can evaporate the water vapor. Most common is a shoe liner that contains hydrophilic fibers that draw moisture from the sock material. Socks that are extremely hydrophobic (polypropylene) repel water so effectively that wicking cannot occur. The mechanical structure of the fiber and the compressibility of the fiber determine the overall wicking capacity. The fibers that wick moisture the best are (best to worst): acrylic, polypropylene, wool, cotton.

Socks Construction

Socks are knitted, giving them stretch and the ability to conform to the foot and leg. Generally, a stockinette or plain knit stitch is used in the foot area and a rib stitch is used in the leg area (though some socks are made totally of rib stitch). The rib stitch is very stretchy, with the ability to return to shape. As

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both the stockinette and rib stitches are simple knit constructions, the stitch can ravel out if a yarn is broken. Look carefully at socks for loose threads, broken yarns, or holes that could start to run or ravel with wear. Also, look for evenly knitted stitches on socks and a flat seam at the toe. Toe seams placed high over the toe are usually more comfortable than those at the end of the toe. Both the toe and heel areas should be smooth; otherwise irritation could occur during wear, found by Joyse Smith *et al.,* (2000).

Uses of nylon

Well-known for its strength and superior chemical as well as biological resistance, nylon finds extensive usage in industrial applications. Parachute and tent fabrics, automobile upholstery, ropes, socks, tyre cords, conveyor belts, mosquito nets and bristles for hair and tooth brushes are common objects made using nylon.

Finishes

Few finishes are applied to socks. A more common finish for socks is one that resists the buildup of odor and bacteria. The feet are among the three areas of the body that contain large sweat glands (the other two are the armpits and the palms of the hands). Feet wrapped in a layer of socks and shoes for long periods become warm and perspire.

Although perspiration is odorless and 99% water, it provides a perfect medium for bacteria to grow. The bacteria cause foot odor. Anti-bacterial agents in the fiber reduce bacteria growth and resulting odor. Most anti-bacterial finishes used today are durable and remain after repeated launderings. (Gulbrandson, *et al* 1992). Such finishes enhance the fabric's moisture-holding power. Chemicals such as ammonium compounds, humectants and wetting agents are generally combined to impart absorbent finish. Wicking and moisture transport properties are important as they leave the body feeling dry and comfortable.

Microbes are the tiniest creatures not seen by the naked eye. They include a variety of micro organisms like bacteria, fungi, algae and viruses. Anti-microbial also referred to as *bacteriostatic* or *antiseptic finishes*. As the terms suggest, these suppress growth of microbes, including disease and rot causing bacteria as well as mildew producing fungi. Socks are given the antimicrobial finish to combat the problem of foul odour caused by heavy perspiration.

Chemicals used to impart this finish include quaternary ammonium compounds, melamine resins with zinc nitrate, hydrogen peroxide along with acidic acid and zinc acetate, copper zirconium compounds and at times even antibiotics. Some natural dyes too have inherent antimicrobial properties, making fabrics dyed them resistant to germs.

Antibacterial fabrics are important not only in medical applications but also in terms of daily life usage. The application of antimicrobial finishes to textiles can prevent bacterial growth on textiles (Jakimiak *et al.,* 2006).

Antibacterial textile production has become increasingly prominent for hygienic and medical applications. The antimicrobial agents can be antibiotics, formaldehyde, heavy metal ions (silver, copper) (Gouda, 2006; Seshadri and Bhat, 2005) quaternary ammonium salts with long hydrocarbon chains (Goldsmith et al., 1954; Lashen, 1971; Seshadri and Bhat, 2005), phenol and oxidizing agents such as chlorine (Goldsmith *et al.,* 1954), chloramines, hydrogen peroxide, ozone (Gouda, 2006).

Quaternary ammonium compounds (quats, qac)

Quaternary ammonium cations, also known as quats, are positively charged polyatomic ions of the structure NR_4^+, R being an alkyl group or an aryl group. Quaternary ammonium salts are used as disinfectants, surfactants, fabric softeners, and as antistatic agents (e.g. in shampoos). Quaternary ammonium compounds have also been shown to have antimicrobial activity. Certain quaternary ammonium compounds, especially those containing long alkyl chains, are used as antimicrobials and disinfectants.

It is also good against fungi, amoeba, and enveloped viruses, quats act by disrupting the cell membrane. Quaternary ammonium compounds are lethal to a wide variety of organisms except endospores, *Mycobacterium tuberculosis* and non-enveloped viruses.

Table 1. Preparation of Super absorbent solution with anti-microbial and anti-odour Property

Chemical Substance	Percentage (%)			
	Trial I	Trial II	Trial III	Trial IV
Sodium Bicarbonate	1-5	5-10	5-10	5-10
Calcium Carbonate	1-2.5	1-5	1-5	1-2.5
Pottasium Ferrocyanide	1-2.5	1-5	1-5	1-2.5
Carboxymethyl Cellulose	30	20	10	5
AM-1000 (QAC)	30	40	50	70
Fragrant or Scent	25	10	10	5
Sodium Alginate	1-5	5-10	5-10	1-5

Materials

Chemicals Used

To make the super absorbent solution the following chemicals are used in various concentrations.

1. Carboxymethyl Cellulose (CMC-Moisture Absorbent Agent)
2. Sodium Bicarbonate (Leavening Agent)
3. Calcium Carbonate (Anti-caking Agent)
4. Potassium Ferro cyanide (Anti-caking Agent)
5. Quaternary Ammonium Compounds (AM 1000-Anti Microbial Agent)
6. Sodium Alginate (Thickening Agent)
7. Fragrance (Anti Odor Agent)

Selection of Fabric: Nylon

Nylon is a generic designation for a family of synthetic polymers known generically as polyamides, first produced on February 28, 1935, by Wallace Carothers at DuPont's research facility at the DuPont Experimental Station. Nylon is one of the most commonly used polymers.

Methods: Preparation of Super Absorbent Solution

The above mentioned solution is preparing by various concentrations is shown in Table- 1. Preparation of Super absorbent solution with anti-microbial and anti-odour Property. To preparing this, the chemicals such as Sodium Bicarbonate, Calcium Carbonate, Pottasium Ferrocyanide, Carboxymethyl Cellulose and Quaternary Ammonium Compounds are used by different concentrations.

The prepared four different concentrated super absorbent solutions were shown in Plates-III, IV, V and VI.

Finishing

The super absorbent polymer liquid was finished on the fabric (Socks) using Dip and dry method and tested for its antibacterial and antifungal activity.

Results and discussion

Antibacterial activity of super absorbent solution by well diffusion method

The antibacterial activity of super absorbent solution by well diffusion method is given in following Table-2

PLATE-III

TRIAL -1 AM-1000 QAC-30%

PLATE-IV

TRIAL -2 AM-1000 QAC-40%

PLATE-V

TRIAL -3 AM-1000 QAC-50%

PLATE-VI

TRIAL -4 AM-1000 QAC-70%

Table-2 Antibacterial activity of super absorbent solution by well diffusion method

Trails	Staphylococcus Aureus (Zone of inhibition in mm)	Eschericia Coli (Zone of inhibition in mm)
1	14	13
2	16	14
3	19	18
4	23	21

From the above Table 2 it is clear that all the four trails were found to be having antibacterial activity against the mentioned organisms.

Evaluation of the water absorbency on textiles by aatcc 79 method

Table 3. Evaluation of the water absorbency on textiles by AATCC 79 method

Sample	Absorbency in seconds
1	2
2	2
3	2
4	2
5(Control)	200

From the above Table-3 it is clear that all the four treated samples were found to be having similar quick absorbency property than the control sample.

Evaluation of the antibacterial on the fabric sample by aatcc 147 method

Table 4. Evaluation of the antibacterial on the fabric sample by AATCC 147 method

S. No	Fabric samples	Zone of Bacteriostasis (mm)				
		Serratia	*Vibrio*	*Staphylococcus aureus*	*Eschericia coli*	*Bacillus*
1	Untreated fabric	0	0	0	0	0
2	Trial 4	25	33	22	0	0

From the above Table-4 it is clear that the treated sample was found to be having anti-bacterial activity against the three organisms.

Evaluation of the antifungal on the fabric sample by aatcc 30 method

Table 5. Evaluation of the antifungal on the fabric sample by AATCC 30 method

S. No.	Sample	Zone of Mycostasis (%) *Trichoderma reesei*
1	Untreated fabric	0
2	Trail 4	40

From the above Table-5 it is clear that the treated sample was found to be having anti-fungal activity to against an organism.

Organoleptic evaluation of odour control test (in-house method)

From the above Table-6 it is clear that the treated samples were to be found fairly good and acceptable according to tested on those subjects.

Anti allergy patch test (contact dermatitis testing)

From the above Table-7 it is clear that the treated sample was found to be there is no any Irritant Reaction according to tested on those subjects.

Conclusion

It may be concluded that the prepared chemical solution is an appropriate material to finish the socks. The finished sample shows good moisture absorbency and having antimicrobial activity when compared with the untreated sample. It has odour control property and also there is no any irritant reaction in contact with skin. Ultimately, it is applicable for athletic persons and also common socks wearers.

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Table 6. Organoleptic evaluation of odour control test (in-house method)

Subjects	Ht (cm) Wt (kg)	SAMPLES	JUDGE 1	JUDGE 2	JUDGE 3	JUDGE 4	AVERAGE
Subject 01 (Male /39 yr)	174/58	Control	2	1	3	2	**2**
		Treated	5	6	5	6	**6**
Subject 02 (Male/29 yr)	178/62	Control	3	2	4	3	**3**
		Treated	6	5	5	6	**5**
Subject 03 (Male/40 yr)	159/54	Control	3	3	3	3	**3**
		Treated	6	7	6	6	**6**

Interpretation: 0 – Repulsive, 1 – Very Poor, 2 – Poor, 3 – Poorly Fair, 4 – Fair, 5 – Acceptable, 6 – Fairly Good, 7 – Good, 8 – Very Good, 9 – Excellent, 10 – Ideal

Table 7. Anti allergy patch test (contact dermatitis testing)

Subjects	Control sample	Treated sample
Subject 01 (Male/21 yrs)	-	-
Subject 02 (Male/30 yrs)	**IR**	-
Subject 03 (Male/35 yrs)	-	-
Subject 04 (Female/22 yrs)	**IR**	-
Subject 05 (Female/25 yrs)	-	-
Subject 06 (Female/29 yrs)	-	-

Interpretation: -: Negative Reaction, IR: Irritant Reaction, +: Positive Reaction**,** ++: Very positive Reaction.

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