

PAPER • OPEN ACCESS

A novel washing algorithm for underarm stain removal

To cite this article: H Acikgoz Tufan *et al* 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **254** 082001

View the [article online](#) for updates and enhancements.

You may also like

- [Osmotic-Capillary Principles for Microfluidic Pumping and Fluid Management for Sweat Sensing Devices](#)
Tamoghna Saha, Jennifer Fang, Sneha Mukherjee et al.
- [Wholistic Electrochemical Biosensor for the Combinatorial Detection of Alcohol and Glucose in Perspired Sweat](#)
Ashlesha Bhide, Sriram Muthukumar and Shalini Prasad
- [\(Invited\) Carbon Nanotube-Based Fabric Sensor for Selective Sodium Detection in Sweat](#)
Chelsea Monty-Bromer, Zachary Cheney, Shelby Daniels et al.



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

A novel washing algorithm for underarm stain removal

H Acikgoz Tufan¹, I Gocek¹, U K Sahin¹ and I Erdem²

¹Istanbul Technical University, Textile Technologies and Design Faculty, Textile Engineering Department, İnönü Cad. No: 65, Beyoğlu/İstanbul, TURKEY

²Arcelik Inc. Washing Machine Plant, Tuzla/İstanbul, TURKEY

Email: acikgozh@itu.edu.tr

Abstract. After contacting with human sweat which comprise around 27% sebum, anti-perspirants comprising aluminium chloride or its compounds form a jel-like structure whose solubility in water is very poor. In daily use, this jel-like structure closes sweat pores and hinders wetting of skin by sweat. However, when in contact with garments, they form yellowish stains at the underarm of the garments. These stains are very hard to remove with regular machine washing. In this study, first of all, we focused on understanding and simulating such stain formation on the garments. Two alternative procedures are offered to form jel-like structures. On both procedures, commercially available spray or deo-stick type anti-perspirants, standard acidic and basic sweat solutions and artificial sebum are used to form jel-like structures, and they are applied on fabric in order to get hard stains. Secondly, after simulation of the stain on the fabric, we put our efforts on developing a washing algorithm specifically designed for removal of underarm stains. Eight alternative washing algorithms are offered with varying washing temperature, amounts of detergent, and pre-stain removal procedures. Better algorithm is selected by comparison of Tristimulus Y values after washing.

1. Introduction

Yellowing on armpits occurs due to using deodorants, antiperspirants contributed with sweating and formation of the yellowing in light coloured garments is earlier and causes most of complaints with these garments. Perspiration is a very important way of balancing human body temperature and it is inevitable. 25 % of total amount of water loss from human body in daily life is caused by perspiration under usual inactive circumstances. Human perspiration includes many organic compounds such as; water, inorganic salts, ammonia, urea, uric acid, amino-acids, lactic acid and sugar which depend on individual [1]. Human perspiration is usually an odorless body secretion. However, as bacteria multiply on the skin and resolve down these secretions, the resulting by-products may include a strong, unpleasant odor. The quick formation of odor is expected to support the concept that such a mechanism manages via simple bond cleavage as disputed to a complex bacterial action [2,3].

Sebum is a light yellow, oily substance secreted by the sebaceous glands that keep the skin and hair moisturized. Sebum is made up of triglycerides, free fatty acids, wax esters, squalene, cholesterol esters, and cholesterol. The oil on the surface of the skin isn't just made up of sebum, however. It also includes lipids from skin cells, sweat, and environmental matter. The sebaceous glands produce sebum [4-6].

A numerous number of cosmetic products are implemented topically on and around the body on a daily basis, usually multiple times a day, including not just underarm antiperspirant/deodorant products but also body lotions, body sprays, moisturizing creams, breast firming/enhancing creams and sun care products. These products are not washed off but remain on the skin, allowing for repeated



dermal exposure, absorption and deposition into underlying tissues, which may be further increased by abrasions in the skin created by shaving [7,8].

In this study, we have classified underarm products as antiperspirants and deodorants. Antiperspirant are personal hygiene products intended to control sweating and personal stench. Antiperspirants contain fixings that control sweat and personal stench securely and successfully. They are promptly accessible available as splashes (airborne), sticks, creams or roll-ons. A deodorant is a substance connected to the body to counteract personal stench brought on by the bacterial breakdown of sweat in armpits, feet, and different territories of the body. A subgroup of deodorants, antiperspirants, influence smell and counteract sweating by influencing sweat organs. Antiperspirants are normally connected to the underarms, while deodorants may likewise be utilized on feet and different regions as body splashes. In the United States, the Food and Drug Administration groups and controls most deodorants as makeup, however arranges antiperspirants as over-the-counter drugs [9].

Underarm cosmetics are made of a numerous variety of chemicals put for different functional reasons. Alcohol is an ingredient present in some roll-ons, aerosols and gels. The dynamic elements of antiperspirants and deodorants are regularly dissolve in alcohol since it dries rapidly once connected to the skin and gives a quick feeling of coolness. Aluminum salts are the dynamic fixing in antiperspirants. These salts give a sheltered and successful method for controlling sweat [10]. Aluminum zirconium tetrachlorohydrate gly, a typical antiperspirant, can respond with sweat to make yellow stains on clothing [10]. Underarm liners are a contrasting option to antiperspirants that do not leave stains [11].

The main purpose of washing laundry is to clear away soils and micro-organisms from polluted textiles and to manage hygienic and decontaminated textiles to use. Textiles goes through laundering operation that contain soil elimination with special laundering agents, bleaching, disinfecting, neutralizing and rinsing [12].

2. Materials and Method

2.1. Materials

Rexona® Spray, Lady Speed® Stick and Dove® Stick, which are most commonly preferred underarm products, are selected for experimental design for making more stain in the first step that making deodorant stain operation.

Vanish Kosla Oxi Action® stain removal chemical is used for more effective elimination of stains. 15 gr Vanish is used for each stain strip that will be applied pre-stain removal chemical. During the washing process, IEC 60456 standard detergent at IEC standards and OMO® commercial detergent are used. It is calculated that quantity of detergent for 4 kg load is like; $40 + 12 \times 4 = 88$ g according to IEC 60456 standard. In the IEC detergent, there are 77 % basic detergent, 20 % sodium perborate tetrahydrate as a bleach and 3 % tetraethylenediamine as a bleach activator.

100 % cotton material that most preferred in shirts is used in experiments, and basis weight of this shirting fabric is 147 g/m². For observing the yellowing more explicit, white coloured woven plain fabric is chosen, which has a balanced structure whose densities in warp and weft directions are 27 ends/cm and 24 picks/cm. For obtaining required load in the washing machine, etamine cotton fabrics are used as ballast load.

During the project, Arçelik brand BK 8121 BT model is used, which is seen in Figure 1. Load capacity is 8 kg and there are 2 water intakes. The washing machine gets involved in A+++ energy class, besides provides 40 % more energy save compared to other machines in this class. In the machine, there are multisensor features such as weight, temperature, water amount, wash-off, period and voltage sensors.



Figure 1. Washing machine which is used in this study

Datacolor Model 600 is used to measure yellowing on armpits in Tristimulus Y values. Y tristilumus value measured here was accepted by CIE Nr.15.2 1986 because of pointing out the brightness independent from the colour. Measures are done at D65 sunlight with 10° angle.

In this study Thermo Scientific® model Heraeus Oven with 57 litres inside volume is used for drying samples. High temperature environment experimental machine oven, briefly, fitting the term 'Oven' has sensitive heat control about all experiments about heat and is used at different sectors for various purposes such as sterilization, drying, dehumidification, cooking. It is provided equal temperature inside the cabin and environment can be set to any temperature between 5-250 °C with sensitivity of $\pm 1^\circ\text{C}$.

2.2. Method

In order to simulate stain on underarms, we followed two alternative procedures. For these procedures Rexona® Spray, Lady Speed® Stick and Dove® Stick are used for making deodorant stain on cotton fabrics; Rexona Spray is applied to determined field for 5 seconds from 10 cm distance and both Lady Speed Stick and Dove Stick are spread to the field for 5 tours which are shown in Figure 2.

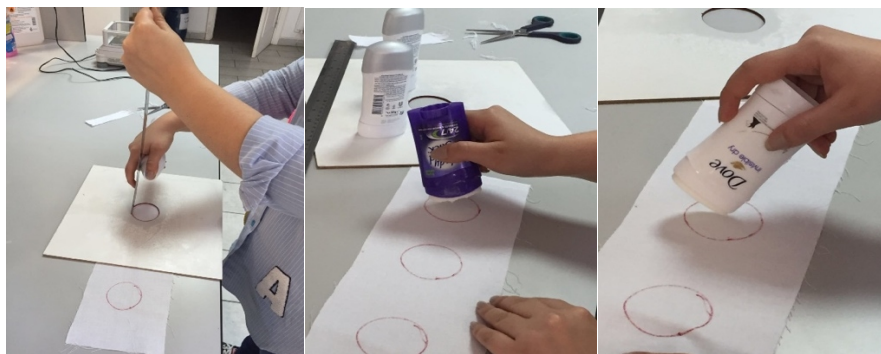


Figure 2. Applying of the underarm products on the fabric

Acidic and basic sweat solutions are put into separate bottles of 2 liters, then 20 sebum fabrics are put into each bottle to get sebum in the sweat solution, that will be simulate sweat stain on human body much more realistic. Experimental cotton shirt fabrics are subsequently immersed into the acidic and basic sweat solutions to wait for 5 minutes and fabrics are taken out. Wet fabrics are covered with polyethylene bag for an hour at 37 °C. After one hour, fabrics are placed in oven and let dry at 40 °C without polyethylene bag. Lastly, all stained and dried fabrics are washed in wooly 40 program. Then the procedure is repeated until the needed stain is achieved. For the second procedure; nearly all steps are performed in first procedure with a little difference; which is addition of 20 sebum fabrics to the sweat solutions is eliminated and addition of these 20 sebum fabrics is carried out in washing step in

wooly 40 program. With this difference second procedure is repeated until obtaining desired stain on cotton fabrics.

To analyze the sufficiency of staining after every staining process Tristimulus Y values was measured and compared to raw fabric colour value, so at the 4th repeat staining process was adequate and it was stopped. Tristimulus Y values before washing is measured by Datacolor Model 600 Spectrophotometer.

After producing sweat stained samples, they are washed in eight different washing algorithms that are created by Design of Experiment (DOE) which are shown in Table 1. Variables of a full-factorial experimental design are temperature (40-60 °C), detergent (IEC and OMO®) and pre-treatment process (applied or not).

Table 1. Experimental design

Profile	Temperature (°C)	Detergent	Pre-treatment
1	40	IEC	NO
2	60	IEC	NO
3	40	OMO	NO
4	60	OMO	NO
5	40	IEC	APPLIED
6	60	IEC	APPLIED
7	40	OMO	APPLIED
8	60	OMO	APPLIED

The baby protect plus program was chosen while washing procedure. The operation was held by heat, pre-stain removal chemistry and detergent variable and constant variable such as water and machine period. The heat is 40 and 60 celcius centigrade, Vanish Kosla Oxi Action is used like pre-stain removal and IEC60456 coded standard detergent and OMO is used as detergent. 15 gr pre-stain removal chemistry is dropped stain strips that contains deodorant. It is put into the machine for washing operation after 15 minutes. Eight profiles were worked starting of these chosen parameters and three stain strips was used for each profile. In Baby Protect Plus program, water is 109 litres and period is 1200 rpm as constant values. Total washing time is 220 minutes. At the end of washing operation colour values of each profiles was measured and was observed how is the removal of stains, then the most suitable washing instruction was determined for these situations.

After washing previously produced stained samples, Tristimulus Y values of these samples are measured by Datacolor 600. In washing machine plants, for evaluating some performance of washing algorithms, Tristimulus Y values are used according to IEC 60456 washing standard. During loading the fabrics to washing machine IEC 60456 standard is also used. Quantity of complementary fabrics to complete the total loading of 4 kg, cotton fabrics are used in the experiments. While loading the machine to share these loads equally 7 complementary fabrics and 1 cotton stained fabric was loaded three times respectively.

By calculating stain removal percentage, which is related with before and after Tristimulus values, we comment on efficiency of algorithms on cleaning; stain removal formula (1) can be found in IEC 60456 washing standard and shown below.

$$\text{Stain Removal (\%)} = \frac{\left(\begin{array}{c} \text{Tristimulus Y} \\ \text{value of soiled fabric} \\ \text{after washing} \end{array} \right) - \left(\begin{array}{c} \text{Tristimulus Y} \\ \text{value of soiled fabric} \\ \text{before washing} \end{array} \right)}{\left(\begin{array}{c} \text{Tristimulus Y} \\ \text{value of unsoiled fabric} \\ \text{before washing} \end{array} \right) - \left(\begin{array}{c} \text{Tristimulus Y} \\ \text{value of soiled fabric} \\ \text{before washing} \end{array} \right)} \times 100 \quad (1)$$

MiniTab® Statistical Analysis software is used to evaluate test results and ANOVA is performed.

3. Results and Discussion

Analysis related with this study was performed by Minitab® ANOVA. When the effect of parameters on stain removal of Rexona spray is considered, it is seen from Figure 3, that commercial laundry detergent, namely OMO, has a positive effect on stain removal that is provided by ingredients of commercial detergent. Because, commercial detergents include enzymes, whitening agents, alkalis, etc. which are enhancing removing of the stain from surface of the fabric. Effect of temperature on stain removal is found as expected that, algorithms with higher temperature resulted with more efficient Rexona stain removal. Application of pre-treatment agent before laundering, which is another parameter of experimental design, showed the most significant stain removal percentage due to high amount of bleaching agent in its composition.

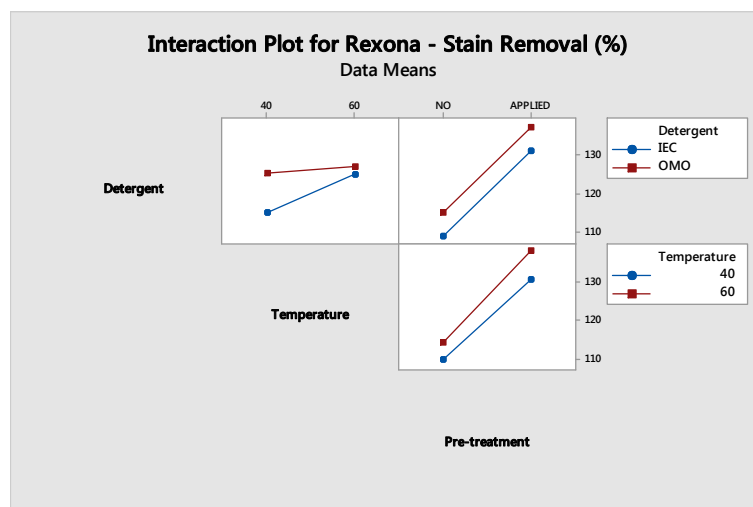


Figure 3: Interaction of parameters on stain removal of Rexona

Contrary to Rexona deodorant stain removal, commercial detergent has no significant effect on removal of Dove stick stain. IEC (standard detergent) and OMO (commercial detergent) have nearly same stain removal results. High temperature in algorithms provides better stain removal with a small difference, which is negligible. Application of pre-treatment in laundering of Dove stick stain has a negative effect for stain removal probably due to fixation of stain as a result of interaction between pre-treatment chemical and Dove stain.

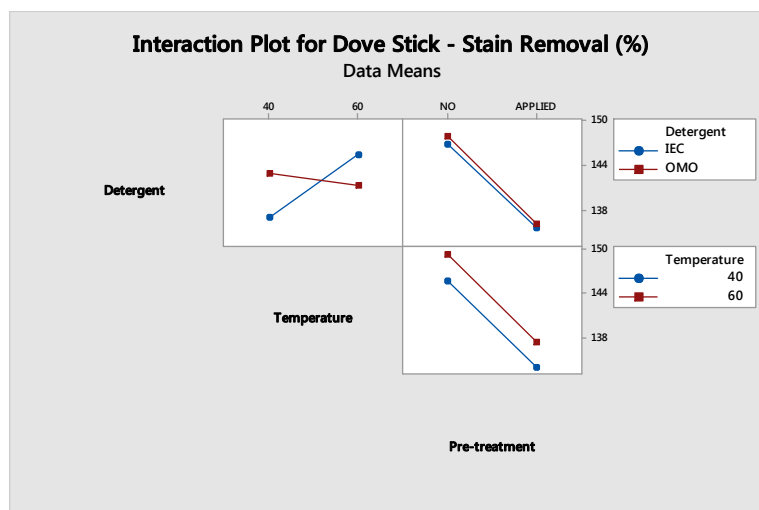


Figure 4: Interaction of parameters on stain removal of Dove

It is apparent that non-surfactant ingredients of the commercial detergent are affected by the oxidation power of pre-treatment chemical which results in a slight decrease for the overall washing performance of commercial detergent. Moreover, removal of Lady Speed stick stain is examined and it is seen from Figure 5 that higher temperature in algorithms mostly results in better stain removal. The slight difference between performances at 40 °C and 60 °C for OMO® may be attributed to the difference of enzyme activities at related temperatures.

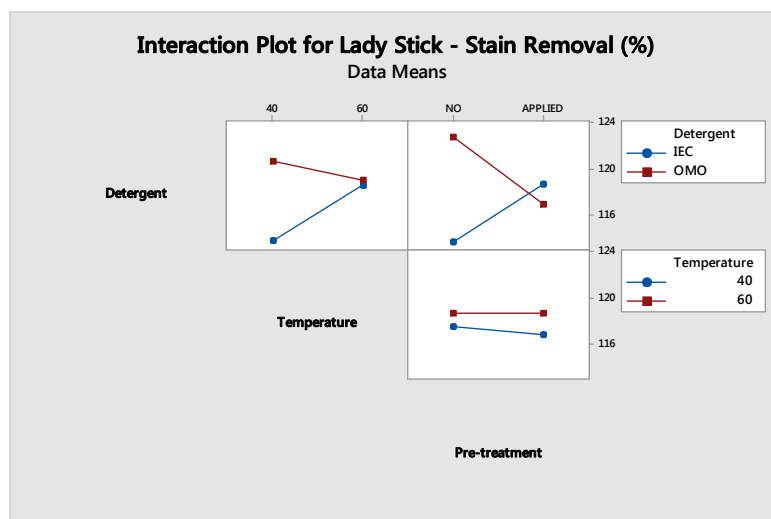


Figure 5: Interaction of parameters on stain removal of Lady

According to these results, higher temperature in washing process, in other words, 60 °C is more effective on removal of stains. Moreover, using of commercial detergent (OMO®) has a positive effect on removal of stains; because of containing higher amount of bleaching agent. Pre-treatment agent used in this study also has a significant effect on removal of stains, which can be seen in Figure 3. For Rexona Spray stain, removal of stain is about 110 % without using pre-treatment agent, which increases dramatically as high as 135 % when using pre-treatment agent. On the stain made by Rexona® Spray by applying pre-stain removal chemical 25 % more efficient cleaning is provided.

4. Conclusion

According to results of algorithms created with parameters of temperature, detergent type, application of pre-treatment process; it is found that temperature has no significant effect on stain removal, a suitable temperature can be selected related with care label. Application of pre-treatment agent obviously has a beneficial effect on removal of underarm stains, presence of high volume of bleaching agents in Vanish improves removal of stains. However, results show that interaction of pre-treatment agent with commercial detergent may result in a limited stain removal performance.

Acknowledgment

This work was supported by the ARCELIK Incorporation Washing Machine Plant, TURKEY. The authors would like to sincerely express their highest appreciations and gratitudes to the members of the system improvement team of ARCELIK Washing Machine Plant, ARCELIK Washing Efficiency Laboratory and ARCELIK Textile Technologies Laboratory.

References

- [1] McSwinry B A 1934 *The Composition of Human Perspiration* (Samuel Hyde Memorial Lecture) Samuel Hyde Memorial Lecture *Journal of the Royal Society of Medicine* 27 7 839-848
- [2] Zeng X N Leyden J J Lawley H J Sawano K Nohara I Preti G 1991 Analysis of characteristic odors from human male axillae *Journal of Chemical Ecology* 17 1469

- [3] Pandey S K Kim K H 2011 Human body-odor components and their determination *TrAC Trends in Analytical Chemistry* 30 5 784-796
- [4] Kucukaydogan N 2012 Sağlıklı derinin nem, sebum ve Ph değişikliklerinin menstrual siklus ile ilişkisi, Adnan Menderes University Medicine Science PhD Thesis
- [5] Burgdorf W H C Plewig G Wolff H H Landthaler M 2009 *Dermatology* (Berlin: Springer Verlag) 993-1018
- [6] Turan N 2010 Akne Vulgaris ve Rosea hastalarında deri, sebum, ph ve nem değerlerinin demodex enfestasyonuna etkisi İnönü University Medicine Science PhD Thesis
- [7] Darbre P D 2001 Underarm cosmetics are a cause of breast cancer *European Journal of Cancer Prevention* 10 389-393
- [8] Darbre P D 2003 Underarm cosmetics and breast cancer *Journal of Applied Toxicology* 23 89-95
- [9] Cosmetics Q&A Personal care products U.S. Food and Drug Administration
- [10] Unilever Facts about sweating www.antiperspirantsinfo.com
- [11] Jarvis S 2014 Excessive sweating (Hyperhidrosis)
- [12] Fijan S Sostar Turk A Cencic A 2005 Implementation of hygiene monitoring systems in hospital laundries *Journal of Hospital Infection* 61 1 30-38