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ELECTROSTATIC CHARGE GENERATED FROM FRICTIONBETWEEN SURGEON SCRUB SUITAND DISPOSABLE COVERS IN HOSPITALS

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ABSTRACT

Electrostatic charges (ESC), generated from friction ofsurgeon scrub suitand disposable covers of polyester, have negative effect in health of the wearer. ESC building up on human skin are very harmful and can create serious health problems. Besides, the electric field generated from ESC can influence the efficiency of the electric appliances used in hospitals. The present study investigates ESC generated from the contact and separation as well as sliding of thesurgeon Scrub Suit and disposable covers of patients and people who are working in hospitals.

Friction coefficientdisplayed by sliding ofsurgeon scrub suitagainst surgical disposable and patient covers decreased with increasing normal load. It is necessary that friction coefficient should have reasonable values so that the disposable cover should adhere well to the surgeon scrub suit to decrease friction between them that is responsible for generating ESC.Surgeon scrub suit as cotton generated positive ESC, while surgical and patient covers showed negative values. As the load increased, ESC increased due to the increased contact area, where the charge transfer became easier.

Based on the relatively high values of ESC generated on the tested materials, it is necessary to propose suchmaterials of relatively low ability to generate ESC to decrease the danger of exposure of the patient and hospital team workers to electric field generated from ESC.

KEYWORDS

Electrostatic charge, friction coefficient, contact and separation, Surgeon scrub suit, disposable cover, hospitals.

INTRODUCTION

Human body is exposed to electric fields that generated from the contact and separation as well as friction of the contact surfaces. Electrostatic charges are usually very near to people bodies, the fields we are exposed from them can be dangerous. For instance, rubbing of polyester blouse over a nylon bra can generate a thousand volts on the fabric surfaces [1 – 3]. The sliding of human skin on hair, African, Asian hair and artificial hair was tested. It was found that significant increase of ESC was observed, [4, 5]. ESC can

severely damage sensitive electronic appliances used in monitoring the condition of the patients in hospitals, where ESC can be more than 25,000 volts. It is well known that when two different materials contact each other, they may get charged. This phenomenon is known as triboelectrification when, [6 - 8]. Charge transfer is divided into electron transfer (metal contact), ion transfer, and material transfer, [9 – 12]. Electron transfers only happen on the insulator surfaces, [13 – 15]. Triboelectric series was introduced to predict the polarity of the charge transferred from one surface to another, [16 - 17]. When two kinds of materials contact each other, the upper one in the triboelectric series will get positively charged and the other one will be negatively charged.

ESC generated from rubbing between shoes and carpet are more dangerous, [18 - 20]. It was proved that water sprayed on the carpet leaks ESC out of the contact surfaces, [21, 22]. These observations confirm the role of humidity on decreasing ESC. Polymers have low mobility, strong localization and trapping ability of ESC, [23]. Applying external stress can release ESC, [24], followed by dielectric breakdown, rupture or wear. Upholstery materials of car seat covers generated significant voltage increase when slid against clothes, [25 - 30]. Polypropylene textiles displayed relatively higher voltage than that shown for high density polyethylene.

The present study investigates the friction coefficient and ESC generated from the dry contact and separation as well as sliding of surgeon scrub suit material and disposable cover materials of patients and people working in hospitals.

EXPERIMENTAL

The present work measured the friction coefficient and ESC generated from the contact and separation as well as drysliding of surgeon scrub suit and disposable covers of patients and people working in hospitals. The electrostatic fields (voltage) measuring device (Ultra Stable Surface DC Voltmeter) was used to measure the electrostatic charge (electrostatic field), Fig. 1. It measures down to 1/10 volt on a surface, and up to 20,000 volts (20 kV). Readings are normally done with the sensor 25 mm apart from the surface being tested.

Fig. 1 Electrostatic field measuring device.

The tested disposable cover (surgical and patient), Figs. 2 - 4, in form of sheet of 400 × 400 mm^2 was adhered to the base of the test rig. Surgeon scrub suit material was wrapped on wooden block and loaded by hand on the cover, Fig. 5. Tests were carried out at room temperature under varying normal loads up to 120 N. The base was supported by two load cells, the first can measure the horizontal force (friction force) and the second can measure the vertical force (normal load), Fig. 6. Friction coefficient was determined by the ratio between the friction force and the normal load. The present study investigates the effect of contact and separation as well as sliding ofsurgeon scrub suit against surgical disposable cover on generating ESC. Besides, the same procedure was run on the contact of surgeon scrub suit against patient disposable cover.

Fig. 2 Surgeon scrub suit and cover.

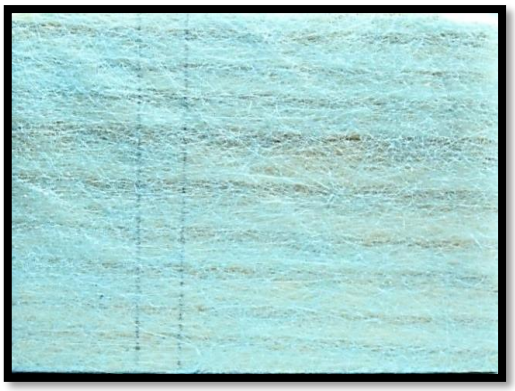

Fig. 3 Disposable surgical cover.

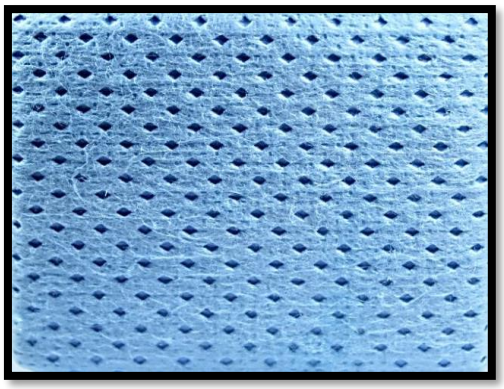

Fig. 4 Disposable patient cover.

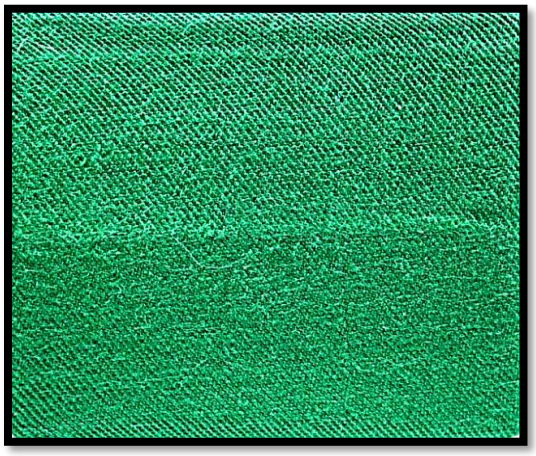

Fig. 5 Surgeon scrub suit textile.

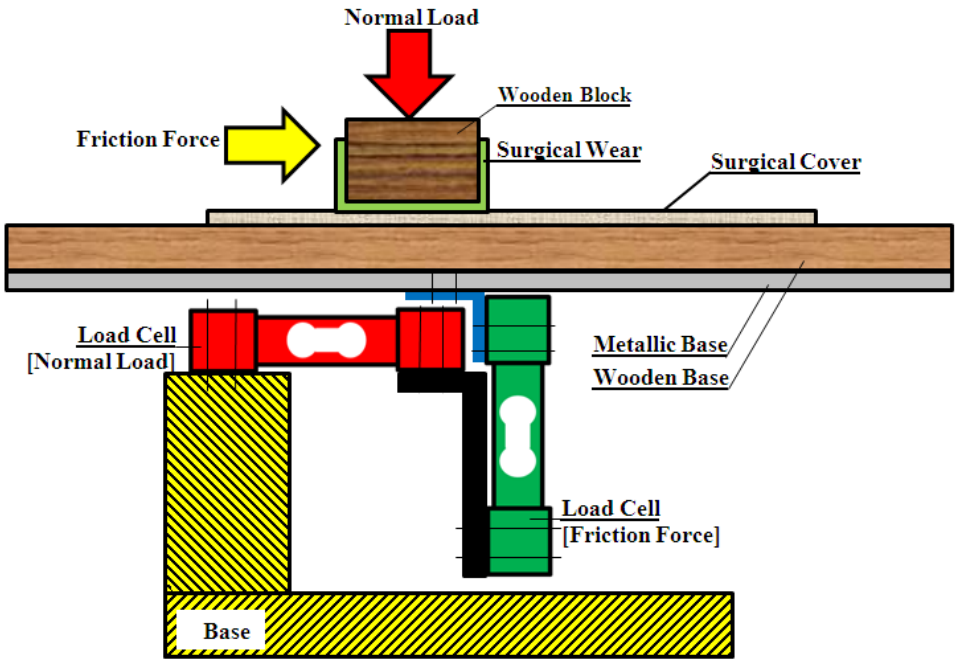

Fig. 6 Arrangement of the test rig.

RESULTS AND DISCUSSION

The results of the experiments carried out to test the friction coefficient and electric static charge from the contact and separation as well as sliding of surgeon scrub suit against surgicaldisposable cover are shown in Figs. 7 – 9. Friction coefficient, Fig. 7, decreased with increasing normal load. It is necessary that friction coefficient should have reasonable values so that the disposable cover should adhere well to thesurgeon scrub suit to decrease friction between them. The lowest friction value was 0.31 at 113 N for dry sliding. As the load increased friction coefficient drastically decreased.

ESC generated on surgeon scrub suit from its contact and separation against surgical cover is illustrated in Fig. 8. Surgeon scrub suit as cotton generated positive ESC of values ranged between 30 and 100 volts, where the values slightly increased with increasing applied load. The load had slight effect on the value of ESC. Surgical cover showed negative values ranging from -450 to -850 volts. As the load increased, ESC increased due to the increased contact area, where the charge transfer became easier.

Sliding of surgeon scrub suit against surgical cover generated much higher ESC, Fig. 9. The highest voltage reached -1250 volts at 118 N measured on the surgical cover. As the load increased, voltage slightly increased for surgeon scrub suit and drastically increased for surgical cover.

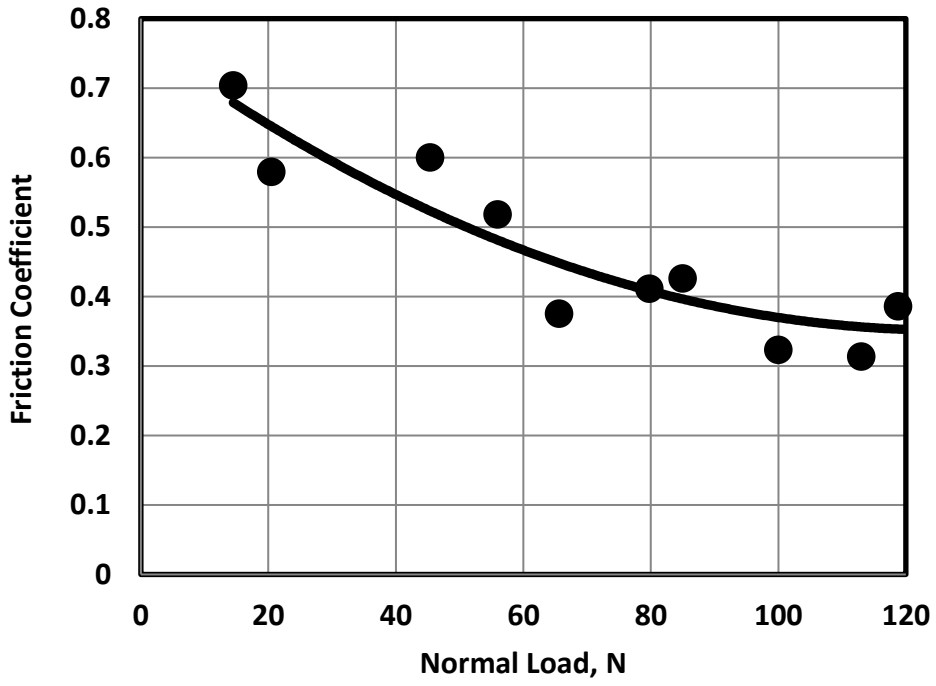

Fig. 7 Friction coefficient displayed by sliding of surgeon scrub suit on surgical disposable cover.

Comfort of textiles is considered as main factor in their evaluation. The measure of the comfort is the friction coefficient displayed between the textiles and skins or other textiles. As the friction coefficient increased, the comfort of the clothes decreased. Friction coefficient displayed by sliding of surgeon scrub suit on patient cover is illustrated in Fig. 10, where the values were lower than that observed for sliding of surgeon scrub suit on his disposable cover. Friction coefficient showed drastic decrease with increasing normal

load. It seems that the relatively smoother surface of patient cover is responsible for the decrease.The lowest friction value recorded 0.31, while the maximum value was 0.52 at 12 N load.

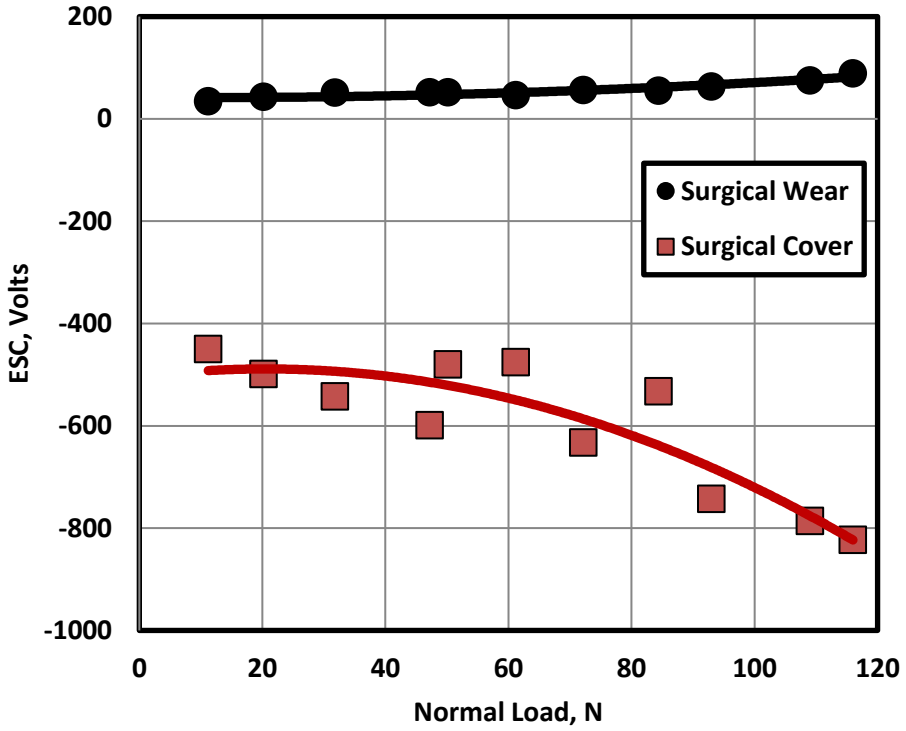

Fig. 8 ESC generated onsurgeon scrub suit and coverfrom their contact and separation.

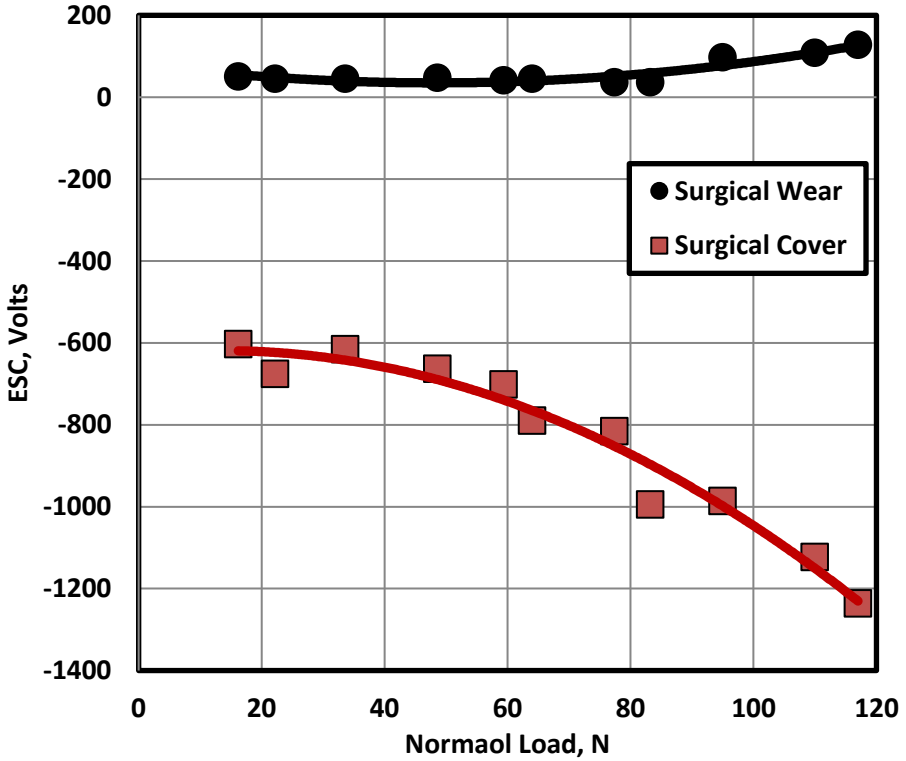

Fig. 9 ESC generated onsurgeon scrub suit and coverfrom their sliding on each other.

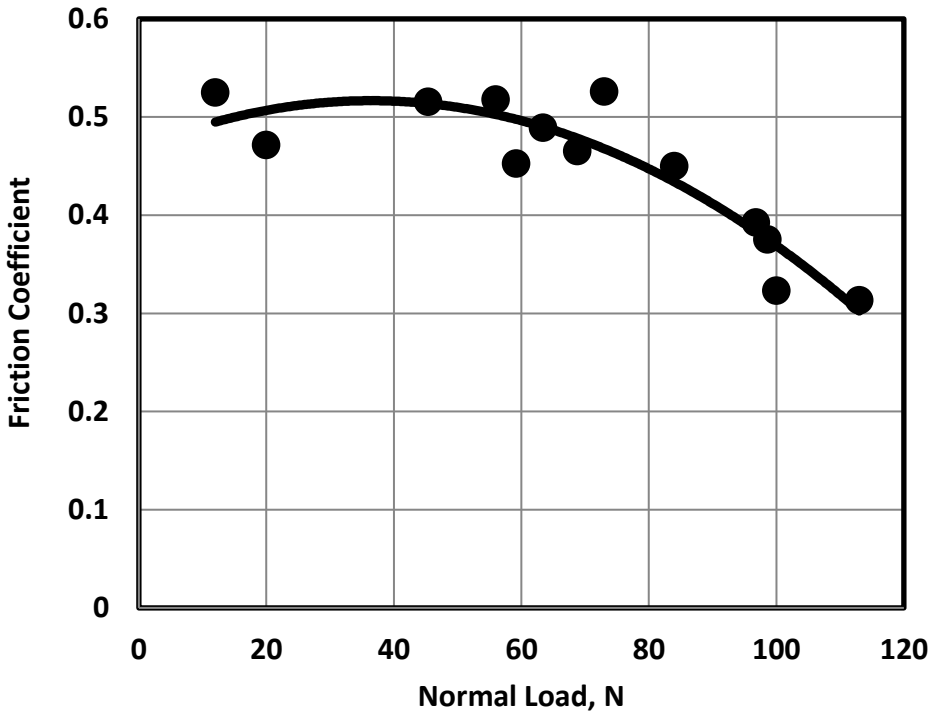

Fig. 10 Friction coefficient displayed by sliding of surgeon scrub suit on patient cover.

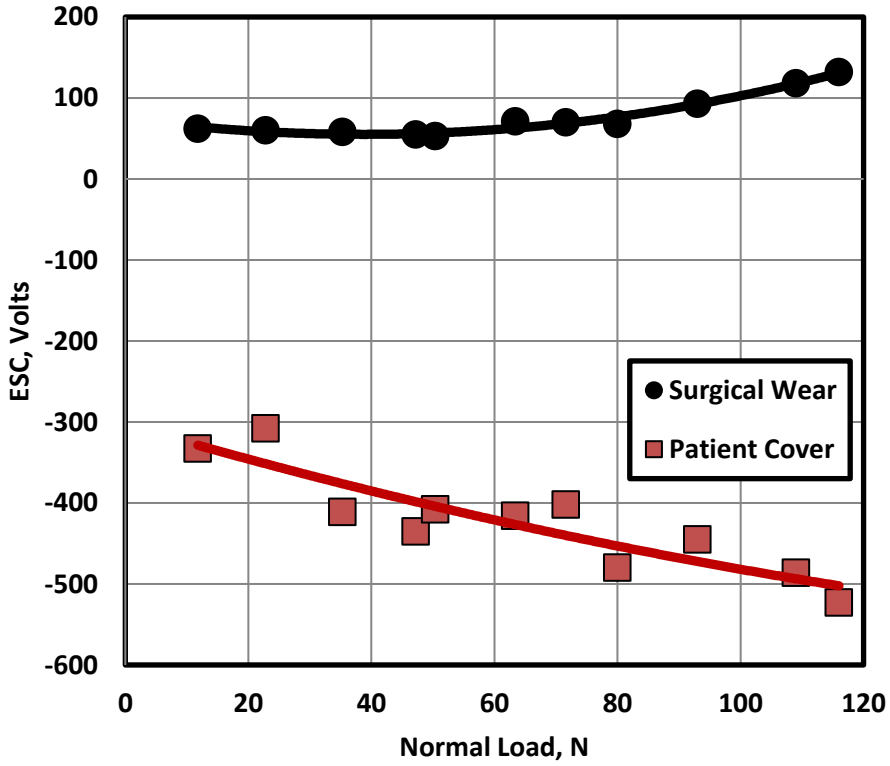

Fig. 11 ESC generated onsurgeon scrub suit and patient coverfrom their contact and separation.

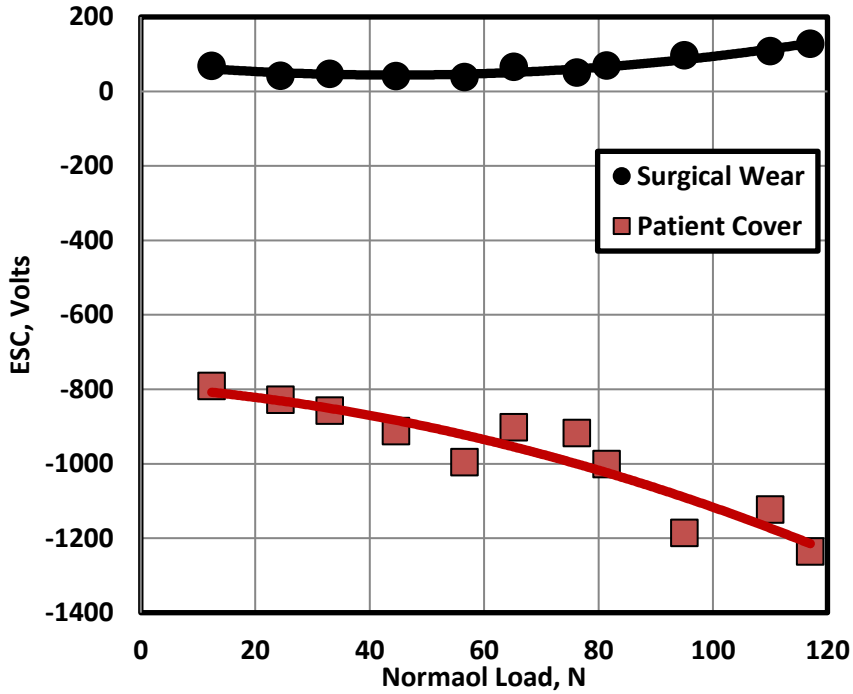

Fig. 12 ESC generated onsurgeon scrub suit and patient coverfrom their sliding on each other.

Figure11 shows ESC generated onsurgeon scrub suit and patient coverfrom their contact and separation, where surgeon scrub suit that made of cotton gained positive ESC, while disposable patient cover of polymeric textile gained negative ESC.It can be seen that increasing the load slightly increasedESC. The highest ESC value (520 volts) was recorded on patient cover at 117 N. The results of experiments measuring ESC generated on surgeon scrub suit and patient cover from their sliding on each other is illustrated in Figs. 12. It is clearly seen that sliding increasedESC compared to values recorded for contact and separation.ESC increase in sliding might be attributed to the increase of the mobility of the free electrons to one of the rubbed surfaces. The fineness of the fibres much influenced the movement of the free electrons. The maximum ESC value was -1250 volts measured on the patient cover.

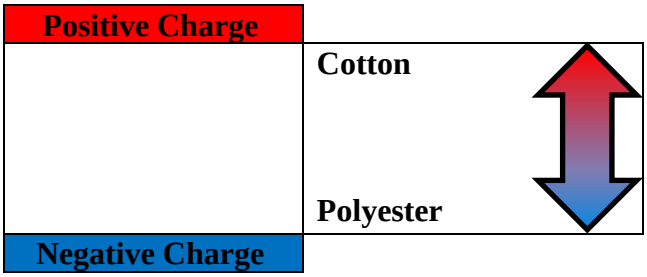

Fig. 13 Illustration of the triboelectric series.

The generated ESC values observed during sliding were enough high to create serious health problems. Based on the experimental observations, it is necessary to propose suchmaterials of relatively low ability to generate ESC. Selection of materials based on their triboelectrification depends on the triboelectric series, Fig. 13. When two different materials get in contact with each other, the first will get positively charged and the other

one will be negatively charged. The increase of the difference in the rank of the two materials in the triboelectric series increases the intensity of ESC and consequently the voltage increases. It is expected that disposable cover (polyester) gains negative charge when rubs cotton wear that gains positive charge.

CONCLUSIONS

1. Friction coefficientdisplayed by sliding of surgeon scrub suit against disposable coverdecreased with increasing normal load.
2. ESC generated on surgeon scrub suit from its contact and separation against surgical coverrecorded values up to 100 volts. Surgeon scrub suit (cotton) generated positive ESC, while surgical cover (polyester) showed negative values which reached 850 volts. As the load increased ESC increased.
3. Sliding of surgeon scrub suit against surgical and patient covers generated higher ESC than that recorded for contact and separation and reached 1250 volts on patient cover.
4. Friction coefficient displayed by sliding of surgeon scrub suit on patient covershowed lower values than that observed for sliding of surgeon scrub suit on his disposable cover.
5. It is recommended to utilizematerials have relatively low ability to generate ESC.

REFERNCES

1. Gray J. R., Frith C. H., and Parker D. J., "Cancer Growth Acceleration by External Electrostatic Fields", Proceedings of the Electrostatics Society of America Annual Conference, (2004).
2. Bhattacharjee P., "Electrostatic discharge hazards and control measures", in Reliability, Infocom Technologies and Optimization (ICRITO) (Trends and Future Directions), 2015 4th International Conference, pp. 1 - 3, (2015).
3. Amsc N. and Reli A., "Military handbook electrostatic discharge control handbook for protection of electrical and electronic parts, assemblies and equipment (excluding electrically initiated explosive devices)(metric)", (1991).
4. Ahmed Fouly, Badran A. H. and Ali W. Y., "A Study on the Electrostatic Charge Generated From the Friction of Wig Cap Textiles against Human Skin and Hair", International Journal of Engineering and Information Systems (IJEAIS), Vol. 2 Issue 7, July – 2018, pp. 25 – 33, (2018).
5. Al-Osaimy, A. S., Mohamed, M. K. and Ali, W. Y., "Friction Coefficient and Electric Static Charge of Head Scarf Textiles", Journal of the Egyptian Society of Tribology Vol. 9, No. 3, July 2012, pp. 24 – 39, (2012).
6. Wu G., Li J., Xu Z., "Triboelectrostatic separation for granular plastic waste recycling: A review", Waste Management 33, pp. 585 – 597, (2013).
7. Lowell J., Rose-Inne A. C., "Contact electrification", Adv. Phys. 29, pp. 947 – 1023, (1980).
8. Matsusaka S., Maruyama H., Matsuyama T., Ghadiri M., "Triboelectric charging of powders: a review", Chem. Eng. Sci. 65, pp. 5781 – 5807, (2010).
9. Lee L. H. (2003), "Dual mechanism for metal–polymer contact electrification", J. Electrostat. 32, 1 - 29, (1994).
10. Matsusaka S., Masuda H., "Electrostatics of particles" Adv. Powder Technol. 14, pp. 143 – 166, (2001).
11. Saurenbach F., Wollmann D., Terris B., Diaz A., "Force microscopy of ioncontaining polymer surfaces: morphology and charge structure" Langmuir 8, pp. 1199 – 1203, (1992).
12. Harper W., "The Volta effect as a cause of static electrification", Proc. Roy. Soc. Lond. Ser. A. Math. Phys. Sci. 205, pp. 83 – 103, (1951).

13. Anderson J., "A comparison of experimental data and model predictions for tribocharging of two-component electrophotographic developers", J. Imag. Sci. Technol. 38, pp. 378 – 382, (1994).
14. Gutman E., Hartmann, G., "Triboelectric properties of two-component developers for xerography" J. Imaging Sci. Technol. 36, pp. 335 – 349, (1992).
15. Yoshida M., Ii N., Shimosaka, A., Shirakawa, Y., Hidaka, J., "Experimental and theoretical approaches to charging behavior of polymer particles", Chem. Eng. Sci. 61, pp. 2239 – 2248, (2006).
16. Park C. H., Park J. K., Jeon H. S., Chu B. C., "Triboelectric series and charging properties of plastics using the designed vertical-reciprocation charger", J. Electrostat, 66, pp. 578 – 583, (2008).
17. Meurig W., Williams L."Triboelectric charging in metal-polymer contacts - How to distinguish between electron and material transfer mechanisms", Journal of Electrostatics 71, pp. 53 – 54, (2013).
18. Matsuyama T., Yamamoto H., "Impact charging of particulate materials", Chemical Engineering Science, 61, pp. 2230 – 2238, (2006).
21. Greason W. D., "Investigation of a test methodology for triboelectrification", Journal of Electrostatics, 49, pp. 245 – 56, (2000).
19. Nomura T., Satoh T., Masuda H., "The environment humidity effect on the tribocharge of powder", Powder Technology (135 - 136), pp. 43 – 49, (2003).
20. Diaz, A. F, Felix-Navarro R. M., "A semi-quantitative tribo-electric series for polymeric materials", Journal of Electrostatics, 62, pp. 277 - 290, (2004).
21. Nemeth E., Albrecht V., Schubert G., Simon F., "Polymer tribo-electric charging: dependence on thermodynamic surface properties and relative humidity", Journal of Electrostatics, 58, pp. 3 – 16, (2003).
22. Blaise G., "Charge localization and transport in disordered dielectric materials", J. Electrostat. 50, pp. 69 – 89, (2001).
23. Berriche Y., Vallayer J., Trabelsi R., Tréheux D., "Severe wear mechanisms in Al_2O_3–AlON ceramic composite, J. Eur. Ceram. Soc. 20, pp. 1311–1318, (2000).
24. Shoush K. A., Mohamed M. K. ,Zaini H. and Ali W. Y., "Measurement of Static Electricity Generated from Contact and Separation of Clothes and Car Seat Covers", International Journal of Scientific & Engineering Research, Volume 4, Issue 10, October-2013 , pp. 1 – 6, (2013).
25. Al-Qaham Y., Mohamed M. K. and Ali W. Y., "Electric Static Charge Generated From the Friction of Textiles", Journal of the Egyptian Society of Tribology Vol. 10, No. 2, April 2013, pp. 45 – 56, (2013).
26. Zaini H., Alahmadi A., Ali A. S. and Ali W. Y., "Electric Static Charge Generated from Contact of Surgical Gloves and Cover in Hospitals", International Journal of Materials Chemistry and Physics, Vol. 1, No. 3, pp. 323 – 329, December (2015).
27. El-Sherbiny Y. M., Ali A. S. and Ali W. Y., "Triboelectrification of Shoe Cover and Floor in Hospitals", EGTRIB Journal, Vol. 12, No. 4, October 2015, pp. 1 – 14, (2015).
28. Mahmoud M. M., Abdel-Jaber G. T. and Ali W. Y., "Triboelectrification of Polypropylene Shoe Sliding Against Polyethylene Shoe Cover", Journal of Multidisciplinary Engineering Science and Technology (JMEST), Vol. 2 Issue 11, pp. 2987 – 2993, (2015).
29. Morioka, K., "Hair Follicle-Differentiation under the Electron Microscope, Springer-Verlag, Tokyo, (2005).
30. Bhushan B., La Torre C., "in: B. Bhushan (Ed.), Nanotribology and Nanomechanics - An Introduction", second ed., Springer, Berlin, (2008).