EGTRIB Journal
JOURNAL OF
THE EGYPTIAN SOCIETY OF TRIBOLOGY
VOLUME 19, No. 4, October 2022, pp. 54 - 62 ISSN 2090 - 5882
(Received July 25. 2022, Accepted in final form August 18. 2022) jest.journals.ekb.eg

REDUCING THE ELECTROSTATIC DISCHARGE GENERATED FROM THE CONTACT AND SEPARATION AS WELL AS SLIDING OF POLYMERIC TEXTILES ON COTTON

Suaad H., Mohamed M. K. and Ali W. Y.

Production Engineering and Design Department, Faculty of Engineering, Minia University, P. N. 61111, El-Minia, EGYPT.

ABSTRACT
The quality of clothes depends on the comfort of textiles. The measure of the comfort is the friction displayed by the sliding of the textiles on skin or other textiles as well as the generation of electrostatic charge (ESC). As the friction increased, the comfort of the clothes decreased. The present work discusses the friction and ESC generated from the contact and separation as well as sliding of polymeric textiles on cotton. Test specimens of composites containing polyester (PET) and polyamide (PA) textile fibers were prepared and tested by contact and separation as well as sliding under different loads against cotton textiles. Ultra surface DC Voltmeter was used to measure ESC of the tested textile composites.

It was found that friction coefficient displayed by the sliding of the PET/PA blend strings on cotton textile drastically decreased with increasing PA. At contact and separation with cotton, ESC generated on the surface of the tested blend showed the highest negative values at 100 % PET, then decreased with increasing PA content. While, the positive ESC generated on the surface of the cotton recorded zero value at 80 % PA, then decreased with increasing PA content to record negative values. Sliding displayed relatively higher ESC at 100 % PA than that observed in contact and separation. The zero values of ESC were observed at 93 % PA. ESC generated on the cotton counterface recorded higher values at 100 % PET. As PA content increased, ESC drastically decreased to negative charge at 100 % PA.

KEYWORDS
Polyester, polyamide, fibers, cotton textiles, triboelectric charge, textile materials.

INTRODUCTION
It was found that blending wool and cotton fibers with polymeric ones drastically decreases ESC generated from their friction with each other. As result of that, the proposed blends become environmentally safe textile materials. The suitability of car seat covers to be used in application to enhance the safety and stability of the driver was assessed by the measurement of the generated ESC. At contact and separation of the tested upholstery

materials of car seat covers against the materials of clothes, values of the generated ESC depended on the type of the materials, [1, 2]. Polyamide textiles generated negative voltage. Relatively high ESC increase was observed for synthetic rubber that limits their application. Besides, the potential for textiles to cause friction-induced injuries to skin such as blistering, [3 - 5], should be considered in sport activities. Runners are often bothered with blisters caused by the friction between textile and foot skin. Therefore it is necessary to measure and predict friction and determine the mechanical contacts between foot, sock and shoe during running. Textiles with conductive threads are favorable because they did not give ignitions provided they were adequately earthed.

Friction of clothes sliding against car seat covers was studied, [6]. Five different types of synthetic leather and nine different types of synthetic textiles, were tested. Triboelectrification of the textiles had low attention. Friction coefficient and ESC generated from the friction of hair and head scarf of different textiles materials were investigated, [7 - 15]. Test specimens of head scarf of common textile fibres such as cotton, nylon and polyester were tested by sliding against African and Asian hair. Sliding of cotton head scarf against hair displayed higher friction than that observed by polyester head scarf. While nylon sliding against hair showed the lowest friction.

Electrostatic properties of hair had no attention although these properties are very sensitive to the friction between hair and head scarf textiles. Hair develops ESC when rubbed with human skin, plastic and textiles. Human hair is a good insulator with an extremely high electrical resistance. Due to that, ESC generated on hair is not easily dissipated in dry environments, [16 - 18].

The aim of the present work is to reduce ESC generated from the contact and separation as well as sliding of polyester strings blended by polyamide on cotton. Besides, friction coefficient displayed by the sliding of blend on cotton textiles is determined.

EXPERIMENTAL

ESC was measured in the present experiments by the electrostatic fields (voltage) measuring device, Fig. 1. Readings are normally achieved with the sensor 25 mm apart from the surface being tested.

Fig. 1 Electrostatic field measuring device.

The test specimens were prepared and arranged for the measurements in the surface of a wooden block of 50 × 50 × 10 mm, Fig. 2. Test specimens consisted of PET of 1.0 mm diameter blended by different content of PA strings of 0.5 mm diameter in volumetric ratio of 0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 vol. %. The blend was shaped in forms of plain weaves textiles, Fig. 3.

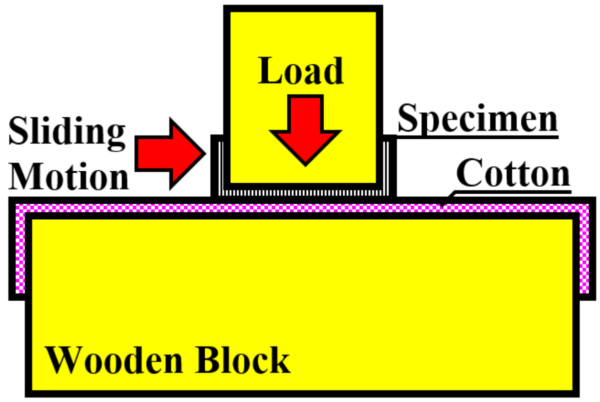

Fig. 2 Arrangement of the teste test procedure.

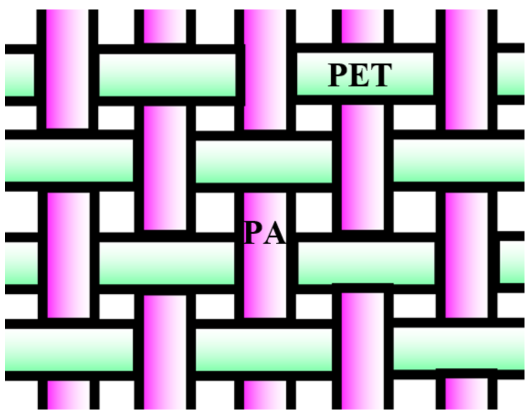

Fig. 3 PET/PA blend test specimen.

Tests carried out to determine friction coefficient were carried out under 0.5, 1.0, 1.5, 2.0 and 2.5 N normal loads. Experiments were carried out by sliding the test blend against the cotton textile. The cotton textiles were placed in a base supported by two load cells, the first measures the friction force, while the second measures the normal load, Fig. 4. Friction coefficient was calculated by the ratio between the friction force and the normal load.

Tests were carried out at room temperature under varying normal loads. The experiments carried out to measure ESC were performed at 20 mm/sec velocity for sliding distance of 200 mm. Besides, at contact and separation, tests were performed. Every experiment was repeated five times and the average value was considered.

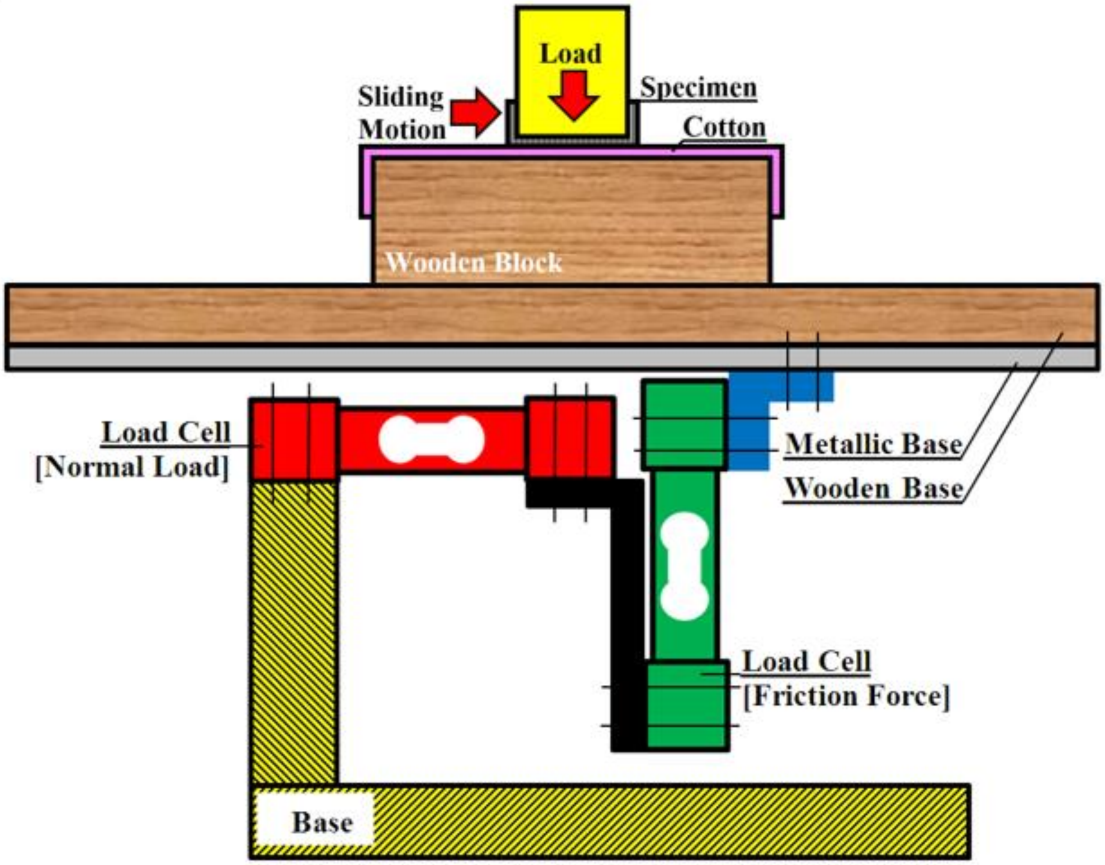

Fig. 4 Test rig to measure the friction.

RESULTS AND DISCUSSION

Friction coefficient displayed by the sliding of the PET/PA blend strings on cotton is shown in Fig. 5, where friction coefficient drastically decreased with increasing PA content. The lowest friction values were observed at 100 wt. % PA content. Those values were 0.124, 0.15, 0.159, 0.191 and 0.205 at 0.5, 1.0, 1.5, 2.0 and 2.5 N respectively. 100 % PET showed the highest friction values that ranged between 0.46 and 0.57 based on the load value. It seems that the addition of PA strings into PET decreased the value of ESC that affected the friction coefficient. Figure 6 illustrates the distribution of ESC on the contact surface at contact and separation as well as sliding. Based on the fact that PET gaines negative charge and PA gaines positive one when they rub cottton, the resultant ESC generated on the two surfaces depends on the relative content of both PET and PA. It is known that the intensity of ESC depends on rank of the contact materials in the triboelectric series where the gap between cotton and nylon is smaller than the gap between PET and cotton. According to the tribo-electric series, the friction between PA and cotton as well as PET and cotton causes the object in the upper position of the series to be positively charged (PA) and that in the lower position to be negatively charged (cotton), while PET gains negative ESC when rub cotton that gains positive ESC. The intensity of ESC of different polarity increases attraction between the two contacting surfaces.

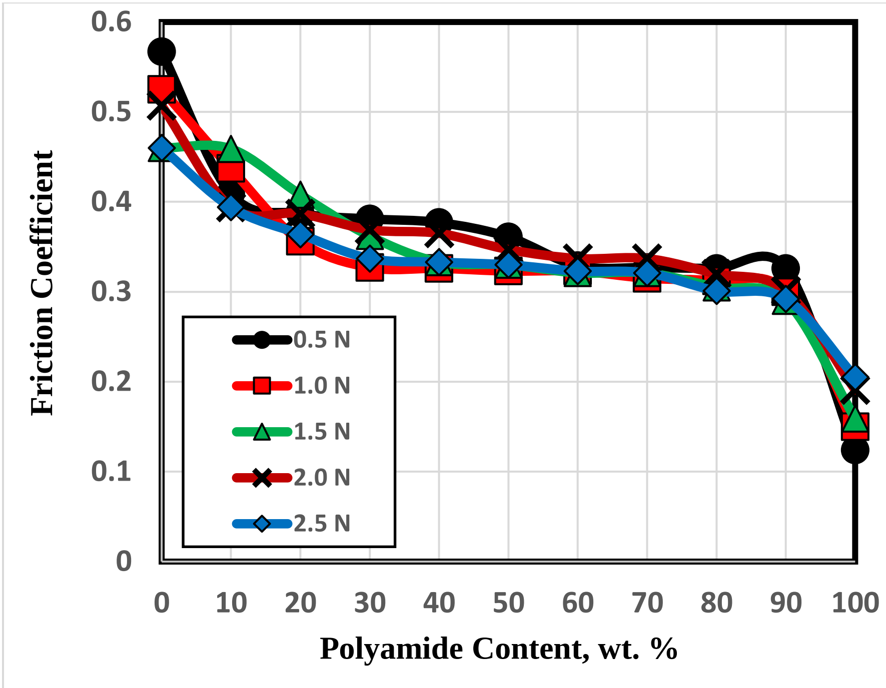

Fig. 5 Friction coefficient displayed by the sliding of PET/PA blend strings against cotton.

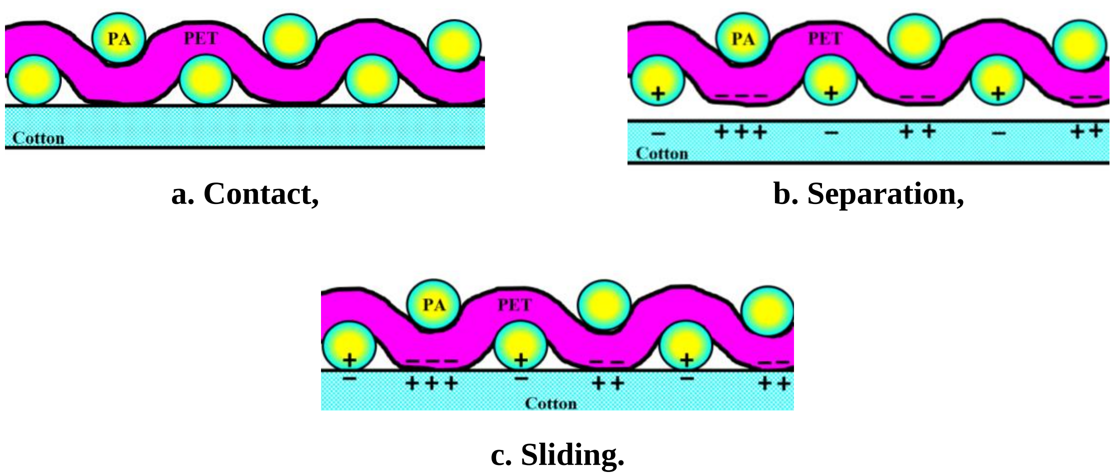

Fig. 6 Representation of ESC generated on the contact surfaces;
a. Contact, b. Separation, c. Sliding.

The results of experiments measuring ESC are illustrated in Figs. 7 – 10. At contact and separation ESC generated on the surface of the proposed polymeric textiles with cotton textile is shown in Fig. 7. The composites of 100 % PET showed the highest negative ESC up to -1096 volts at 10 N load. Then ESC values decreased with increasing PA content due to the increase of the positive ESC. The lowest ESC was observed at 100 % PA at all load values. ESC generated on the surface of the cotton from contact and separation ids illustrated in Fig. 8, where the zero value of ESC was observed at 80 % PA. At 100 % PET content, the values of ESC ranged between 360 to 128 volts for 10 and 2 N

load respectively. Then ESC decreased with increasing PA content to record negative values at PA values of 80 – 100 % content.

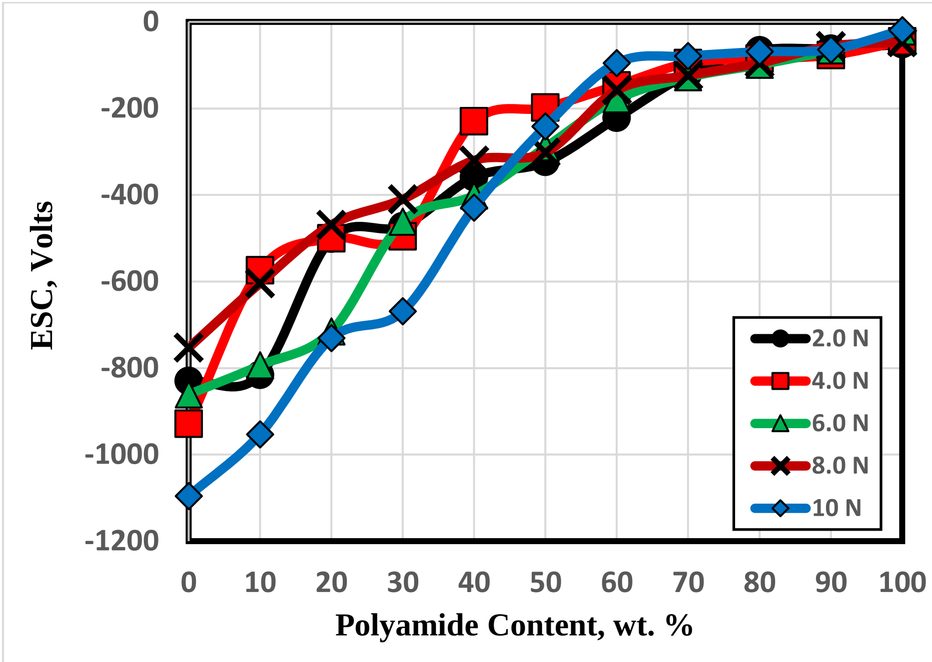

Fig. 7 ESC generated on the tested blend strings from the contact and separation with cotton.

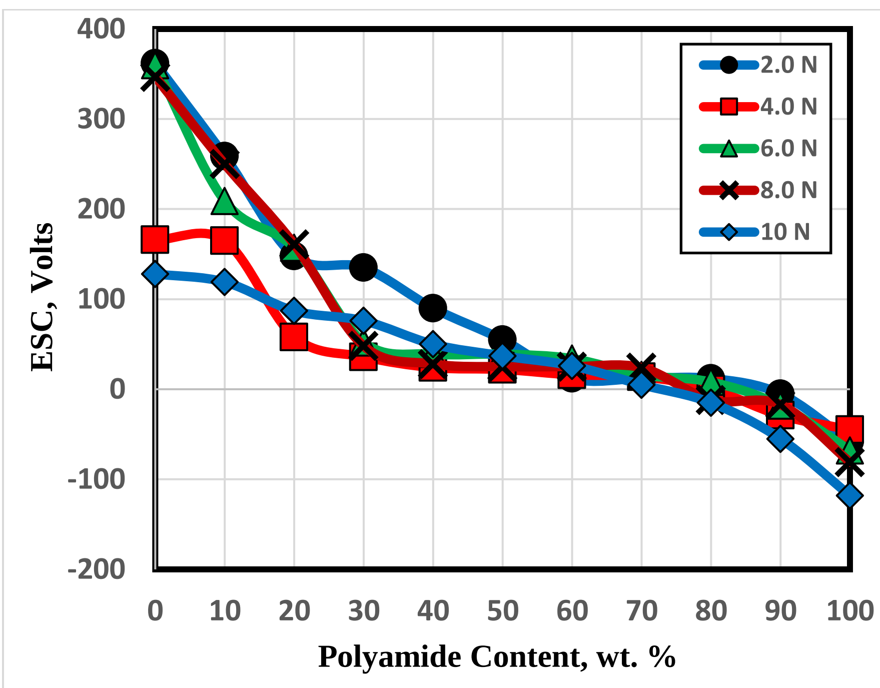

Fig. 8 ESC generated on the cotton surface from the contact and separation with the tested blend.

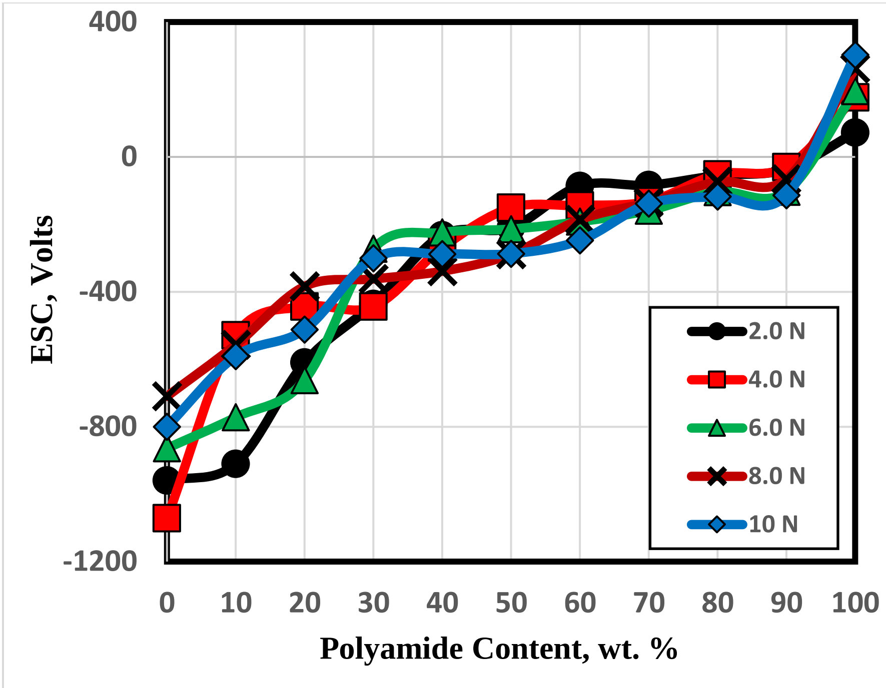

Fig. 9 ESC generated on the tested blend strings sliding on cotton.

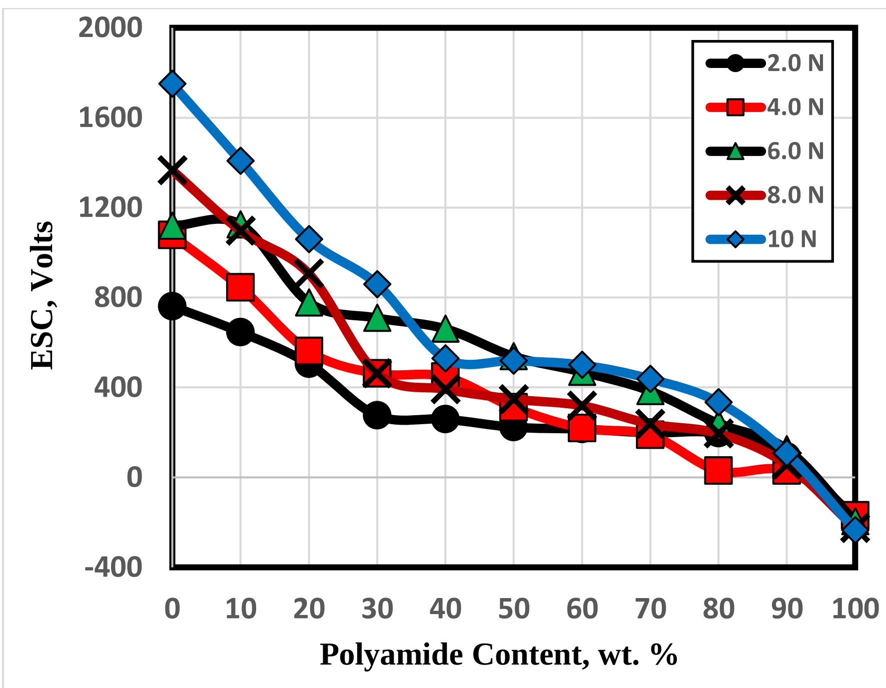

Fig. 10 ESC generated on the cotton surface from sliding on the tested blend.

Sliding of the proposed polymeric textiles against cotton displayed relatively higher vales at 100 % PA than that observed in contact and separation, Fig. 9. The maximum value were 72, 176, 195, 262 and 302 volts at 2, 4, 6, 8 and 10 N respectively. The zero values of ESC

were observed at 93 % PA, while ESC generated on the cotton surface from sliding on the tested blend recorded high values up to 1750 volts at 100 % PET, Fig. 10. As the PA content increased ESC drastically decreased to the minimum at 100 % PA. Considering that PET gaines negative charge and PA gaines positive charge when they are in contact and separation as well as sliding, the resultant ESC would depend on the combination of both PET and PA.

CONCLUSIONS

1. Friction coefficient displayed by the sliding of the PET/PA blend strings on cotton drastically decreased with increasing PA, where the lowest values were observed at 100 % PA content.

2. At contact and separation ESC generated on the surface of the tested blend with cotton recorded the highest negative values at 100 % PET. ESC values decreased with increasing PA content. The lowest ESC was observed at 100 % PA.

3. The positive ESC generated on the surface of the cotton from contact and separation recorded zero value at 80 % PA, then decreased with increasing PA content to record negative values at PA values of 80 – 100 % content.

4. Sliding displayed relatively higher vales at 100 % PA than that observed in contact and separation. The zero values of ESC that represented the optimal desired condition, were observed at 93 % PA. ESC generated on the cotton surface recorded relatively higher values at 100 % PET, then as the PA content increased ESC drastically decreased to the minimum of negative charge at 100 % PA.

REFERENCES

1. 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).

2. Shoush K. A., Mohamed M. K., Zaini H. and 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).

3. Matthew D. A., Christian S. J., "Investigation of skin tribology and its effects on the tactile attributes of polymer fabrics", Wear, Vol. 267, pp. 1289 - 1294, (2009).

4. Derler S., Schrade U., Gerhardt L. C., "Tribology of human skin and mechanical skin equivalents in contact with textiles", Wear, Vol. 263, pp. 1112 - 1116, (2007).

5. Poopathy K., Michael T. J., Juk H., Paul H., Jan L., Gabriele S. L., "Measurements of incendivity of electrostatic discharges from textiles used in personal protective clothing", Journal of Electrostatics, Vol. 49, pp. 51 - 70, (2000).

6. Sulaimany A. A., AlGethami A. A. and Ali W. Y., "Friction Coefficient Between Clothes and Car Seat Covers", Journal of the Egyptian Society of Tribology Vol. 8, No. 4, October 2011, pp. 35 – 46, (2011).

7. 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).

8. 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).
9. Mohamed R. A., Samy A. M., Ali W. Y., "Electric Static Charge and Friction Coefficient of Head Scarf Textiles Sliding Against Hair and Skin", International Journal of Advanced Materials Research, Vol.2, No. 3 (April), pp. 45 – 51, (2016).
10. Abdel-Mageed A. M., Ibrahim R. A., Ali W. Y., "Friction Coefficient of Headscarf Textiles Sliding Against Hair and Skin", International Journal of Advanced Materials Research, Vol.2, N0. 3 (April), pp. 24 – 28, (2016).
11. Esraa S. S., Khansaa A. M., Rasha A. A., Sahar A. K., Sandra E. S., Ali W. Y., "Proper Selection of Foot Wearing Socks Textiles Based on Friction Coefficient Displayed by Sliding Against Indoor Floors", EGTRIB Journal, Vol. 13, No. 2, April 2016, pp. 15 – 24, (2016).
12. Mahmoud M. M., Ali W. Y., "Electric Static Charge Generated from the Sliding of Head Scarf Textiles Against Skin and Hair", International Journal of Scientific & Engineering Research, Volume 4, Issue 9, February - 2016, pp. 375 – 389, (2016).
13. Ali W. Y., AL-Ealy Y., AL-Otaibi A., AL-Zahrany N., AL-Harthy O. and Mohamed M. K., "Triboelectrification of Synthetic Textiles", 1st International Workshop on Mechatronics Education, March 8th -10th 2015, Taif, Saudi Arabia, pp. 264 – 277, (2015).
14. AlEili Y., Mohamed M. K. and Ali W. Y. ,"Triboelectrification of Polymeric Textiles", Journal of the Egyptian Society of Tribology, Vol. 12, No. 1, January 2015, pp. 26 - 35, (2015).
15. 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).
16. Morioka K., "Hair Follicle-Differentiation Under the Electron Microscope, Springer-Verlag, Tokyo, (2005).
17. Bhushan B., La Torre C., "in: B. Bhushan (Ed.), Nanotribology and Nanomechanics - An Introduction", second ed., Springer, Berlin, (2008).
18. Schroder D. K., "Semiconductor Material and Device Characterization", third ed., Wiley, Hoboken, (2006).