EGTRIB Journal

JOURNAL OF
THE EGYPTIAN SOCIETY OF TRIBOLOGY
VOLUME 20, No. 2, April 2023, pp. 66 – 76 ISSN 2090 - 5882

(Received January 28. 2022, Accepted in final form February 27. 2023) jest.journals.ekb.eg

ELECTROSTATIC CHARGE GENERATED FROM THE CONTACT-SEPARATION AND SLIDING OF POLYAMIDE AND POLYESTER STRINGS BLENDED BY CARBON FIBERS 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

Generation of electrostatic charge (ESC) of textiles controls the quality and comfort of clothes. The present work discusses the ESC generated from the contact-separation and sliding of polyamide and polyester strings blended by carbon fiberson cotton. Test specimens of composites containing both polyester (PET) and polyamide (PA) strings were prepared and tested by contact-separation andsliding under different loads against cotton textiles. The ESC generated on the surfaces of the tested materials was measured.

The experimental results revealed that at contact-separation of PET with cotton, ESC generated on the surface of PET blended by CF decreased with increasing CF content. PET free from CF showed the highest negative ESC values. It seems that CF facilitates the conduction of ESC from PET to cotton. At sliding, ESC recorded relatively higher values than that observed at contact-separation, where the effect of CF was significant. PA strings contacting cotton textile displayed relatively lower values than that observed for PET. That behavior can be attributed to that PET strings had fine fibers that increased the area subjected to ESC, while the surface of PA strings is smooth with no fibers. Finally, sliding of the PA strings blended by CF against cotton displayed relatively higher vales at 100 % PA than that observed in contact and separation.

KEYWORDS

Polyester, polyamide,strings, cotton textiles, electrostatic charge, carbon fibers.

INTRODUCTION

Recently, the friction and ESC generated from the contact of polymeric textiles on cotton was discussed, [1]. Test specimens containing polyester (PET) and polyamide (PA) strings were tested sliding against cotton textiles, where thefriction and ESC of

the tested materials were measured. It was revealed that friction coefficient caused by the sliding of the PET/PA blendstringson cottontextile drastically decreased with increasing PA content. ESC generated on the surface of the tested blend showedthe highest negative values at 100 % PET, thendecreased 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. The zero values of ESC at sliding were observed at 93 % PA.Blending wool and cotton fibers with polymeric ones drastically decreasedESC generated from their contact with each other, [2]. Therefore, the proposed blends can be environmentally safe.

In sport activities, the ability oftextiles to cause friction-induced injuries to skin such as blistering, [3 -5], should be taken into consideration, such as blisters caused by the friction between textile and foot skin. It is necessary to determine the mechanical contacts between foot, sock and shoe during walking and running. The best solution is to use textiles with conductive threads provided they were properly earthed.

The applicability of car seat covers to be used depends on the intensity of ESC that influences the comfort and the safety of the driver. The contact of the tested upholstery materials of car seat covers against the clothes generated values of ESCthat dependedon the type of the contact materials, [6 - 8], wherepolyamide textiles generated positive voltage. On the other side, relatively ESC increase was observed for synthetic rubber.

Triboelectrification of the head scarf textiles had low attention. Friction coefficient and ESC generated from the friction of hair and head scarf of different textiles materials were tested, [9 - 16]. The common textile fibers of head scarf such as cotton, nylon and polyester were tested by contact-separation and sliding against African and Asian hair. It was found that sliding displayed higher friction than contact and separation. While nylon showed the lowest friction. Besides, hair developsESC when rubbed human skin, polymers and textiles. Human hair is considered as good insulator with high electrical resistance. According to that, ESCgenerated on hair is not easily dissipated especially in dry environments, [17 - 19].

The aim of the present work is to reduce ESC generated from the contact-separation and sliding of both polyester and polyamide strings blended by carbon fiberson cotton.

EXPERIMENTAL

The ESC was measured by theelectrostatic fields (voltage) measuring device, Fig. 1. The test specimens were prepared for the measurements in the surface of a wooden block of 50 × 50 × 50 mm, Fig. 2. Two groups of test specimens were tested, the first consisted of PET of 1.6 mm diameter while the second was of PA strings of 0.5 mm diameter. The twogroups were blended by different content of CF in content of 0, 2, 4, 6, 8 and 10 wt. %. The blend was shaped in forms of plain weaves textiles, Fig. 3.

Experiments were carried under varying normal loads of 2, 4, 6, 8 and 10 N. The experiments carried out to measure ESC were performed at 20 mm/sec velocity for sliding distance of 200 mm. Every experiment was repeated five times and the average value was considered.

Fig. 1 Electrostatic field measuring device.

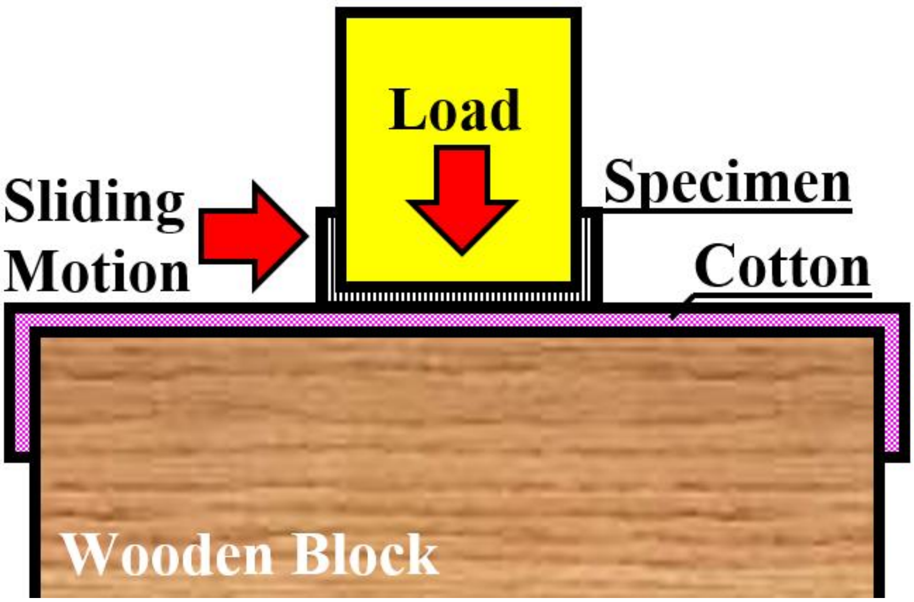

Fig. 2 Arrangement of the teste test procedure.

100 wt. % PA.

100 wt. % PET.

100 wt. % PET and 10 wt. % CF.

Fig. 3 PET and PA test specimens.

RESULTS AND DISCUSSION

ESC generated on the surface of polyester strings of 1.6 mm diameter blended by carbon fibers from the contact-separationwith cotton is shown in Fig. 4. The negative ESC decreased with increasing CF content, wherethe lowest ESC values were observed at 10 wt. % CF content. Those values were -0.14, -0.21, -0.31, 0.54 and 0.69 at 2, 4, 6, 8 and 10 N respectively. 100 % PET showed the highest negative ESC values. It seems that the addition of CF into PET transferred ESC into the cotton surface of positive charge. On the other side, ESC generated on the surface of cotton textile from the contact-separationwithtested blend is shown in Fig. 5. The positive sign of ESC generated on the cotton surface drastically decreased with increasing CF content.

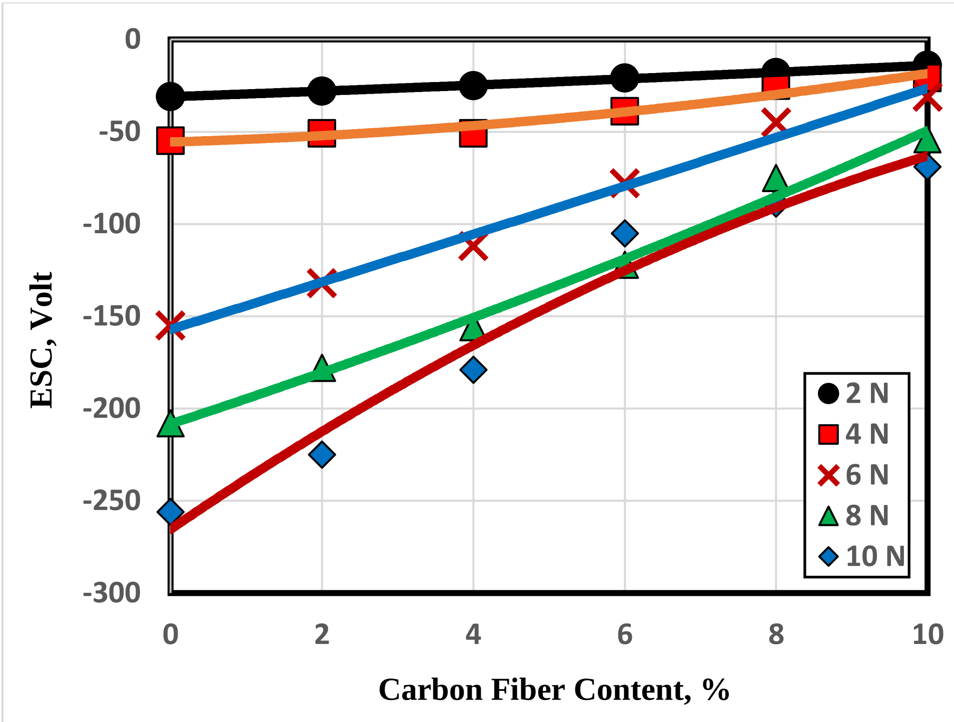

Fig. 4 ESC generated on the surface of polyester strings of 1.6 mm diameter blended by carbon fibers from the contact and separation with cotton.

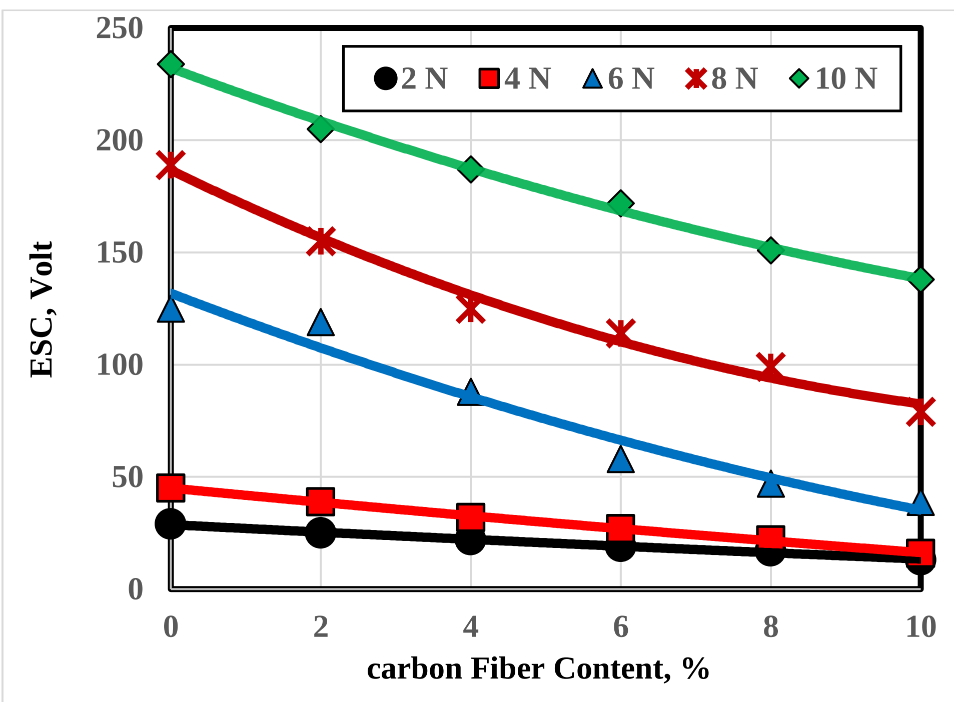

Fig. 5 ESC generated on the surface of cotton textile from the contact-separation with tested blend.

The distribution of ESC on the contact surface at contact-separation and sliding is illustrated in Fig. 6. PET gaines negative charge after rubbing cottton, while cotton gains positive ESC. The presence of CF facilitates the transfer the charge from one surface to the other. The resultant ESC generated on the two surfaces depends on the relative content of CF.It is clear that the intensity of ESC is influenced by therank of the contact materials in the triboelectric series. Based on the tribo-electric series, the contact between PETand cottoncauses the objectin the upper position of the series to be positively charged (cotton) and that in the lower position to be negatively charged (PET).The intensity of ESC of different polarity increases attraction between the two contacting surfaces.

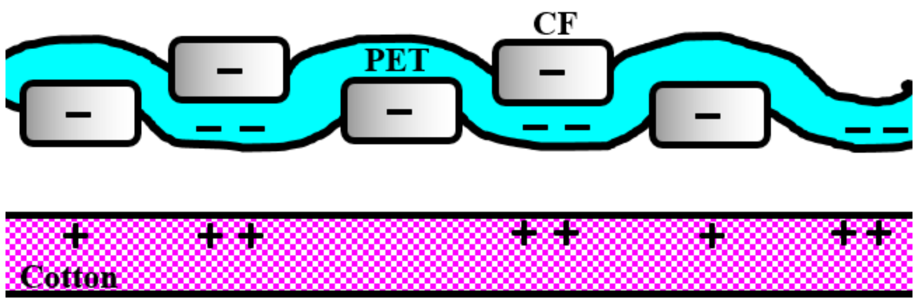

Fig. 6 Representation of ESC generated on the contact surfaces; aftercontact-separation and sliding.

The results of experiments measuring ESC generated from the sliding of polyester strings of 1.6 mm diameter blended by carbon fibers and sliding on cotton are illustrated in Fig. 7, wherePETfree of CF showed the highest negative ESC up to -472 volts at 10 N load. Then ESC values decreased with increasingCF content due to the easy charge transfer offered by the CF. The lowest ESC was observed at 10 %CFat allload 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. ESC generated on the surface of cotton textile is shown in Fig. 8. Generally, at sliding the ESC recorded relatively higher values than that observed for sliding. In addition to that the effect of CF was significant.

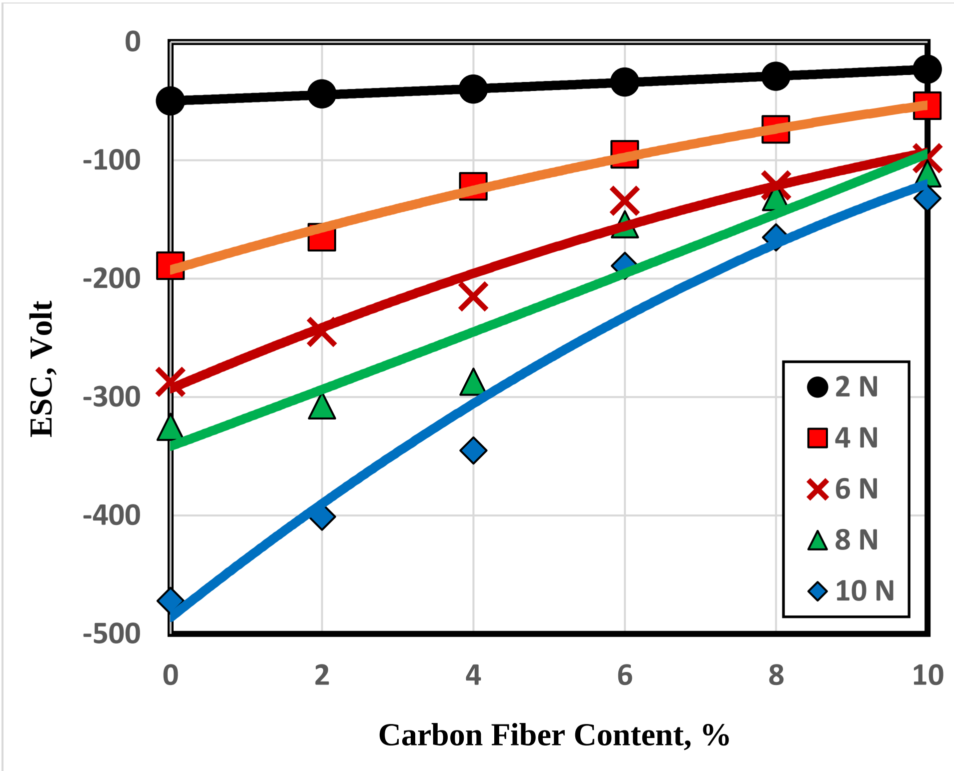

Fig. 7 ESC generated on the surface of polyester strings of 1.6 mm diameter blended by carbon fibers and sliding on cotton.

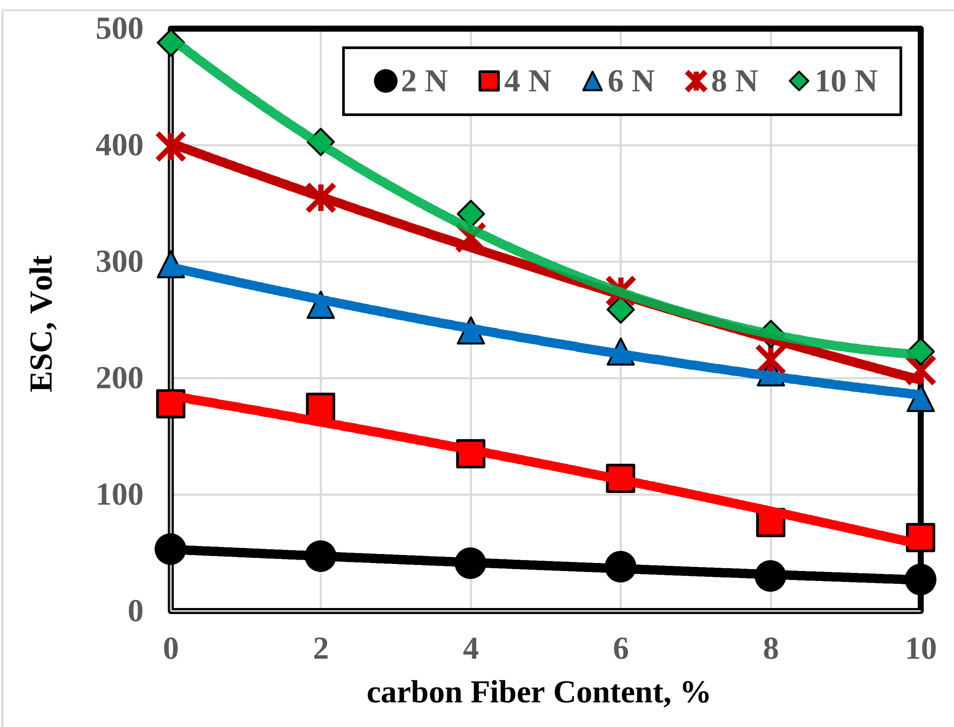

Fig. 8 ESC generated on the surface of cotton textile sliding on the tested blend.

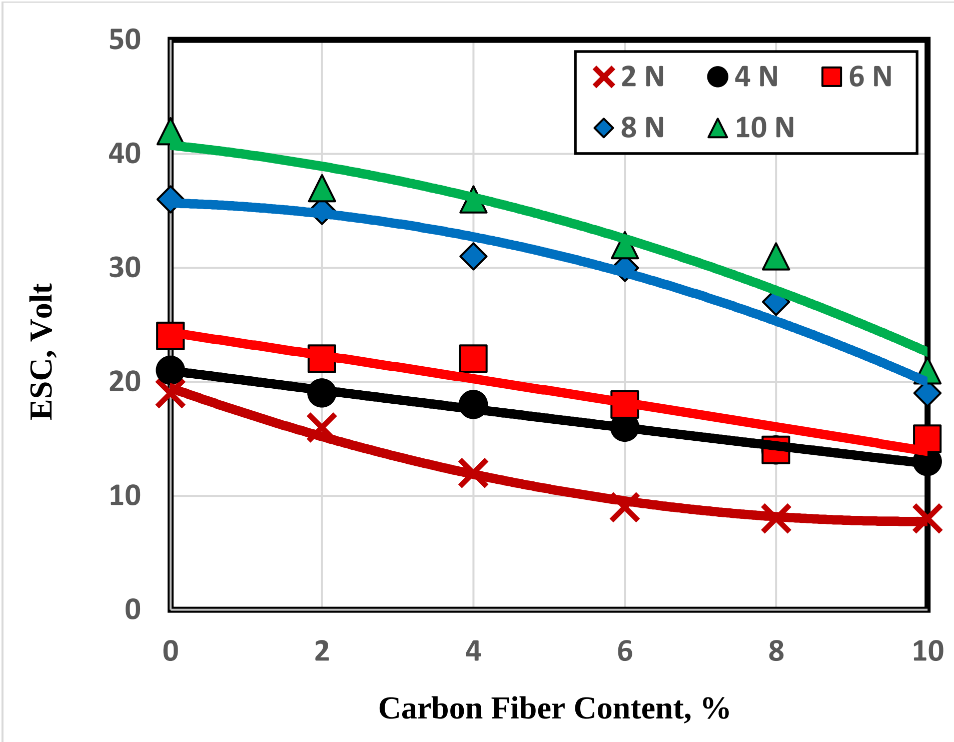

Fig. 9 ESC generated on the surface of polyamide strings of 0.5 mm diameter blended by carbon fibers from the contact-separation with cotton.

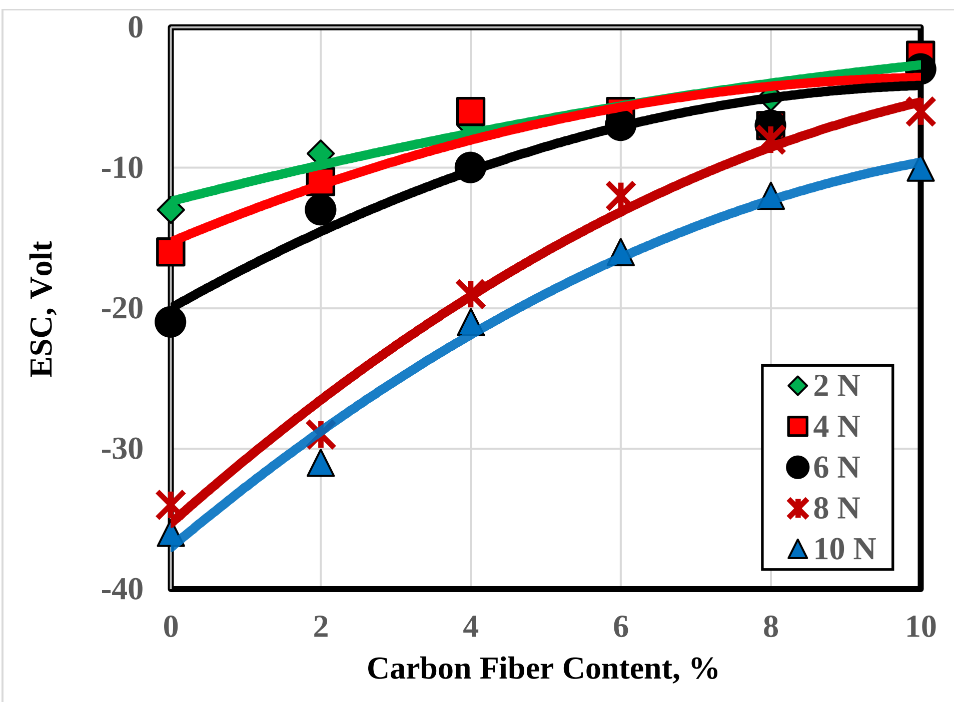

Fig. 10 ESC generated on the surface of cotton textile from the contact-separation with tested blend.

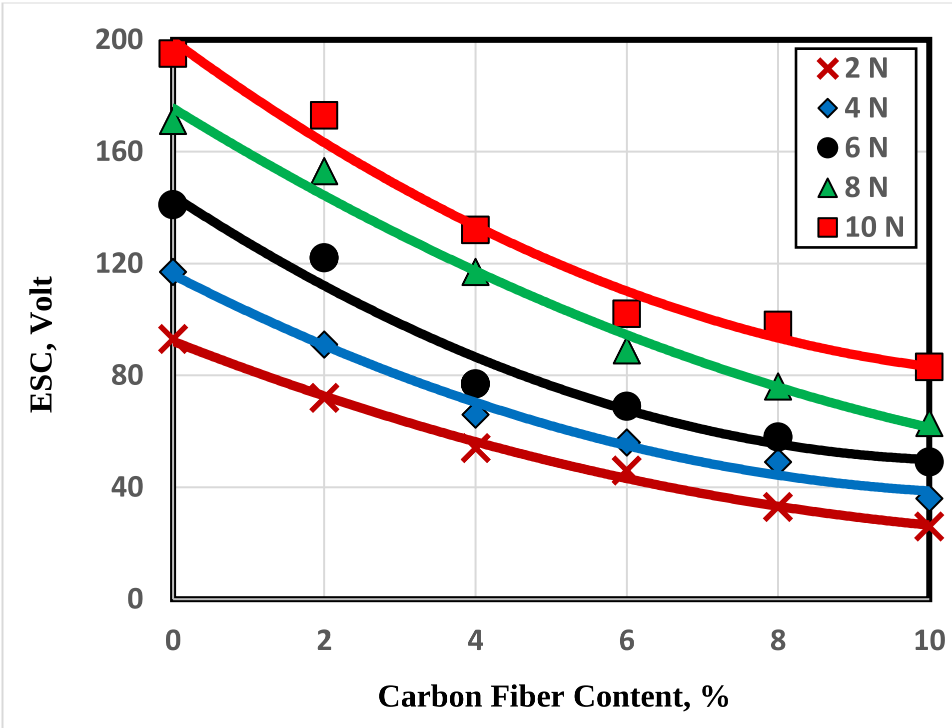

Fig. 11 ESC generated on the surface of polyamide strings of 0.5 mm diameter blended by carbon fibers and sliding on cotton.

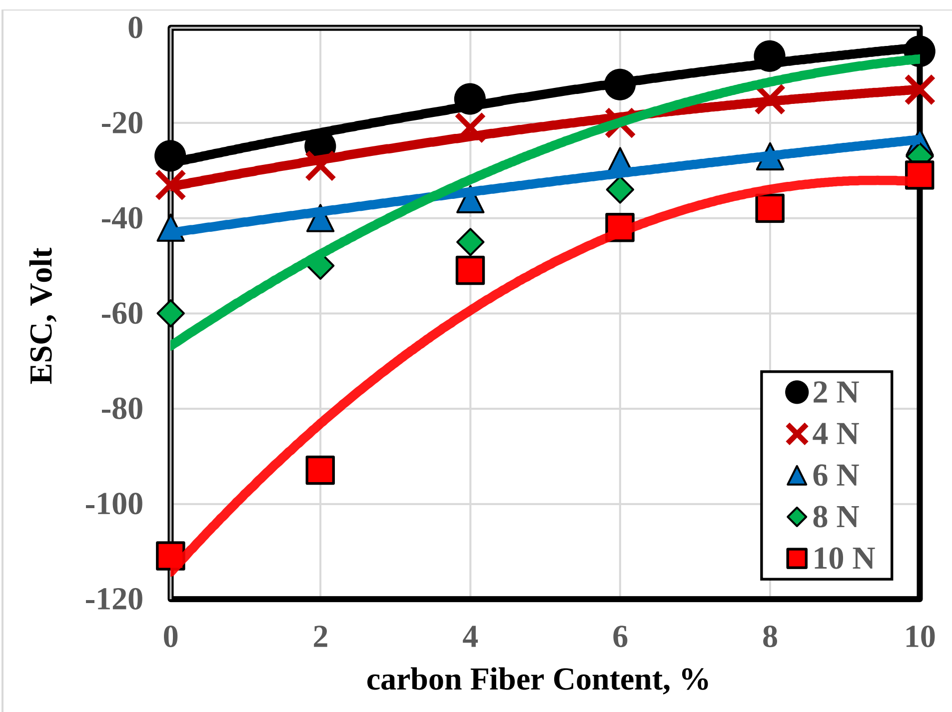

Fig. 12 ESC generated on the surface of cotton textile sliding on the tested blend.

Contact-separation of the specimens of the second group consisting of PA strings contacting cotton textile displayed relatively lower values than that observed for PET, Fig. 9. That behavior can be explained on the basis that PET strings contained fine fibers that increased the area subjected to ESC. In contradiction to that, thesurface of PA strings is smooth with no fibers, Fig. 3. The maximum value, presented by 100 wt. % PA, were 19, 21, 24, 36 and 42 volts at 2, 4, 6, 8 and 10 N respectively. As the CF content increased, ESC decreased.ESC generated on the cotton surface from contact-separation withPA blended by 10 wt. % CF recorded negative ESC of value up to -10 volts at 10 N load, Fig. 10.

Sliding of the PA strings blended by CF against cotton displayed relatively higher vales at 100 % PA than that observed in contact and separation, Fig. 11. The maximum values were displayed by 100 % PA free of CF, then decreased with increasing CF content, while ESC generated on the cotton surface from sliding onthe tested blend recorded -111 volts at 100 % PA, Fig. 12. As the CF content increased, negative ESC decreased to the minimum at 10 wt. % CF.

CONCLUSIONS

1. At contact-separationwith cotton, ESC generated on the surface of polyester strings blended by carbon fibers decreased with increasing CF content, wherethe lowest ESC values were observed at 10 wt. % CF content.
2. PET free from CF showed the highest negative ESC values.
3. The presence of CF facilitates the transfer the charge from one surface to the other, where the resultant ESC depends on the relative content of CF.
4. At sliding, ESC recorded relatively higher values than that observed for sliding. In addition to that the effect of CF was significant.
5. Contact-separation of PA strings contacting cotton textile displayed relatively lower values than that observed for PET.
6. Sliding of the PA strings blended by CF against cotton displayed relatively higher vales at 100 % PA than that observed in contact and separation.

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).
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. 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).

7. 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).
8. 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).
9. 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).
10. 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).
11. 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).
12. 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).
13. 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).
14. 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).
15. 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).
16. 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).
17. Morioka K., "Hair Follicle-Differentiation Under the Electron Microscope, Springer-Verlag, Tokyo, (2005).
18. Bhushan B., La Torre C., "in: B. Bhushan (Ed.), Nanotribology and Nanomechanics - An Introduction", second ed., Springer, Berlin, (2008).
19. Schroder D. K., "Semiconductor Material and Device Characterization", third ed., Wiley, Hoboken, (2006).