EGTRIB Journal
JOURNAL OF
THE EGYPTIAN SOCIETY OF TRIBOLOGY
VOLUME 20, No. 3, July 2023, pp. 1 - 11 **ISSN 2090 - 5882**
(Received January 22. 2023, Accepted in final form April 26. 2023) **jest.journals.ekb.eg**

PROPER SELECTION OF TEXTILES BASED ON ELECTROSTATIC CHARGE GENERATED FROM THEIR CONTACT-SEPARATION AND SLIDING ON WOOL FIBERS

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ABSTRACT
Generation of electrostatic charge (ESC) of textiles due to their contact and friction with other textiles controls the quality and comfort of clothes. In the present work, the ESC generated from the contact-separation and sliding of cotton and polyester (PET) strings blended by carbon fibers on wool fibers is measured. The experiments revealed that ESC generated on the surface of cotton/PET from the contact-separation with wool showed relatively higher negative values that increased with increasing PET content. While, the positive sign of ESC generated on the wool surface remarkably increased with increasing PET content. It was observed that ESC generated on the surface of wool from the sliding on cotton/PET displayed remarkable increase of positive values that may be attributed to the ranking of the cotton, PET and wool in the triboelectric series. It can be concluded that addition of carbon fibers (CF) drastically decreased ESC and consequently the proposed strings will be environmentally safe materials. The drastic decrease of ESC compared to that observed in strings free of CF is attributed to the easy charge transfer offered by CF.

KEYWORDS
Cotton, polyester, wool, strings, electrostatic charge, carbon fibers.

INTRODUCTION
It is worthy that less attention was considered for the triboelectrification of the textiles. Several attempts were carried out to reduce ESC generated from the contact of polymeric textiles on cotton, [1 - 3], either by blending polymeric strings of different electrostatic properties or by CF. Test specimens containing PET and polyamide (PA) strings were tested by sliding against cotton textiles, where ESC of the tested materials was measured. It was revealed that friction coefficient caused by the sliding of the PET/PA blend strings on cotton textile drastically decreased with increasing PA content. 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. The zero values of ESC at sliding were observed at 93 % PA. Blending wool and cotton fibers with polymeric ones drastically decreased ESC generated from their contact with each other, [4 - 6]. Therefore, the proposed blends can be environmentally safe.

In sport activities, the ability of textiles to cause friction-induced injuries to skin such as blistering, [7 - 9], 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.

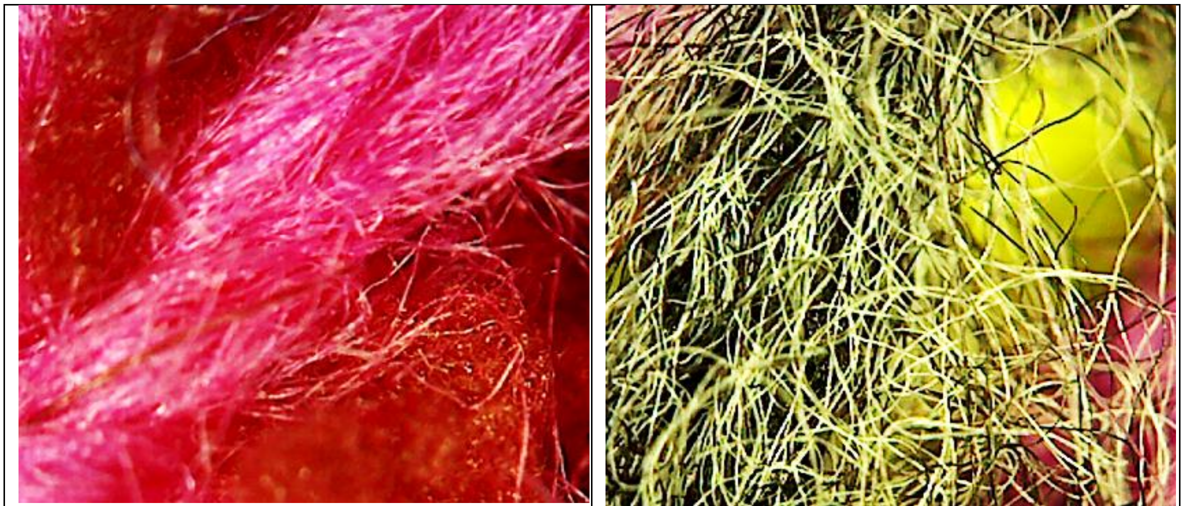
The applicability of car seat covers to be used depends on the intensity of ESC that influences the comfort and the safety of the driver. The contact of the tested upholstery materials of car seat covers against the clothes generated values of ESC that depended on the type of the contact materials, [10 - 12], where polyamide 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, [13 - 18]. 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 develops ESC when rubbed human skin, polymers and textiles. Human hair is considered as good insulator with high electrical resistance. According to that, ESC generated on hair is not easily dissipated especially in dry environments, [19 - 21].

The aim of the present work is to measure ESC generated from the contact-separation and sliding of cotton/PET strings blended by carbon fibers on wool.

EXPERIMENTAL

ESC generated from the contact-separation and sliding of cotton/PET strings blended by carbon fibers, Fig. 1, on wool was measured by the electrostatic fields (voltage) measuring device, Fig. 2, under different normal loads. The test specimens were prepared for the measurement by adhering into the surface of a wooden block of 50 × 50 × 50 mm, Fig. 3. The test specimens were of cotton and PET of 1.0 mm diameter while the wool fibers were of 0.1 mm diameter. The test specimens were blended by 2.0 wt. % CF content. The cotton and PET strings were shaped in forms of plain weaves textiles. 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 at 200 mm sliding distance.



100 wt. % PET.	100 wt. % Cotton.

Fig. 1 PET and cotton test specimens.

Fig. 2 Electrostatic field measuring device.

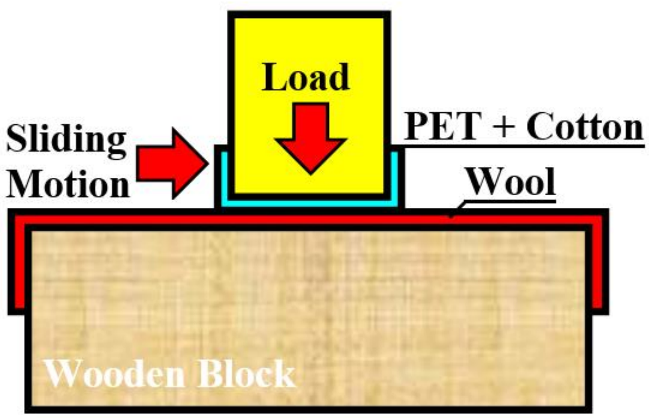


Fig. 3 Arrangement of the test procedure.

RESULTS AND DISCUSSION

ESC generated on the surface of cotton/PET from the contact-separation with wool is shown in Fig. 4. The negative ESC increased with increasing PET content, where the highest negative ESC values were observed at 100 wt. % PET content. Those values were -631, -910, -962, -1257 and -1319 at 2, 4, 6, 8 and 10 N respectively. It seems that the addition of PET into cotton did not reduce the negative ESC. On the other side, ESC generated on the surface of wool fibers from the contact-separation with cotton/PET is shown in Fig. 5. The positive sign of ESC generated on the wool surface remarkably increased with increasing PET content. The ESC represented relatively higher values up to 3946, 4224, 6685, 7446 and 8553 volts at 2, 4, 6, 8 and 10 N load respectively. ESC measured in voltage represented relatively higher values.

ESC generated on the surface of cotton/polyester from the sliding on wool recorded higher values than that observed for contact-separation, Fig. 6. The highest negative values displayed by 100 wt. % PET were -2972, -4702, -5213, -5878 and -6280 volts at 2, 4, 6, 8 and 10 N load respectively. While ESC generated on the surface of wool from the sliding on cotton/PET, Fig. 7, displayed positive values of 10157, 14843, 15651, 18332 and 19632 volts at 2, 4, 6, 8 and 10 N load respectively. The remarkable values of ESC observed for the tested strings may be attributed to the ranking of the cotton, PET and wool in the triboelectric series, Table 1, where the gap among those materials is relatively high.

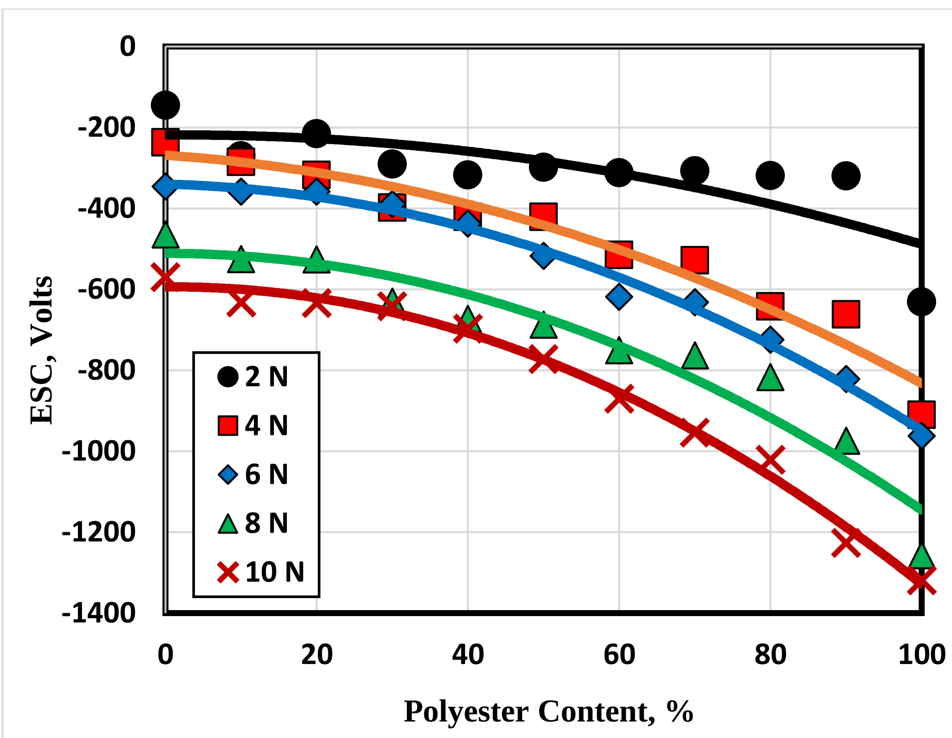


Fig. 4 ESC generated on the surface of cotton/PET from the contact-separation with wool.

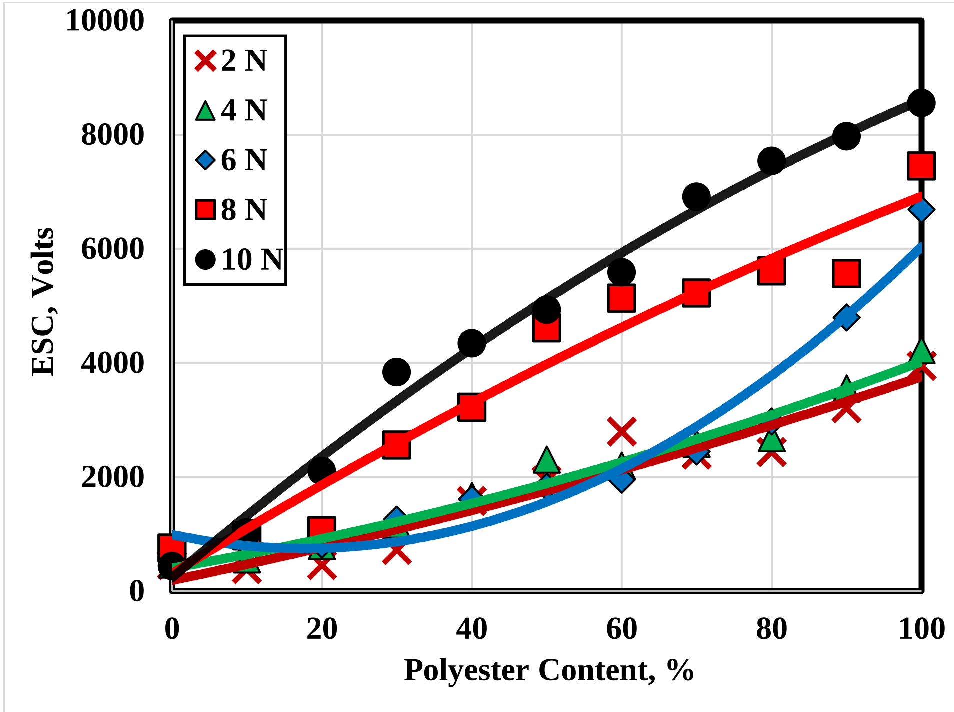


Fig. 5 ESC generated on the surface of wool from the contact-separation with cotton/PET.

Table 1. Triboelectric series of the tested textiles.

POSITIVE CHARGE	
	WOOL
	COTTON
	POLYESTER
NEGATIVE CHARGE	

It is known that the intensity of ESC is dependent on the position of the contact materials in the triboelectric series, where the triboelectric series is used to determine the charge polarity of the materials. When two different materials contact each other, they may get charged. This tribocharging process is known as triboelectrification when materials rub each other, [22]. The charge transfer is electron transfer, ion transfer and material transfer, [23, 24]. The electron transfer mechanism is occurring in metal-metal contact, while ion transfer and material transfer are occurring in the unstrained and strained contact materials. It was found that straining a material can produce charged species that include ions, electrons and radicals that can react to form charged species.

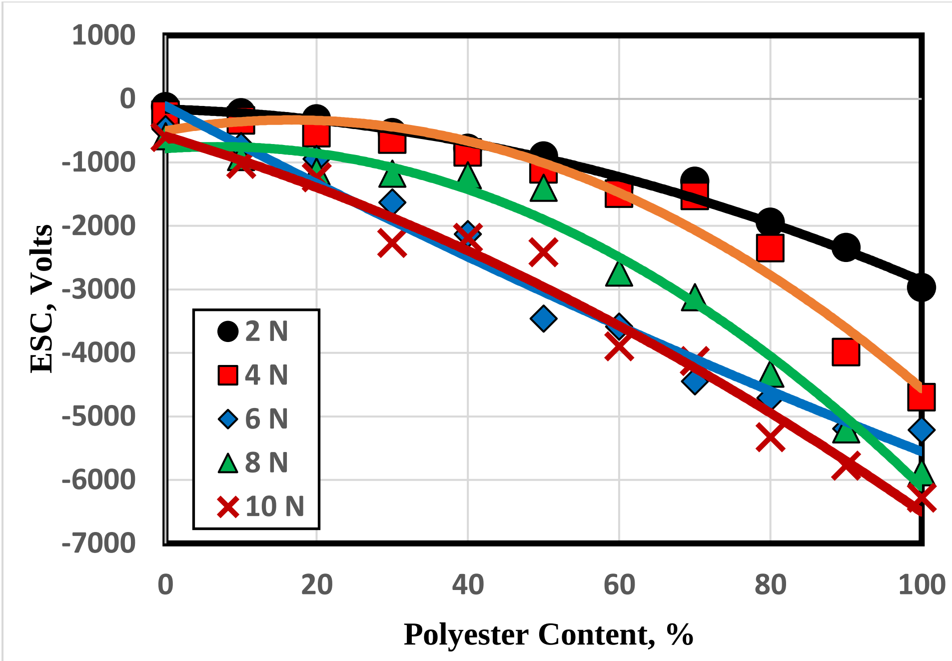


Fig. 6 ESC generated on the surface of cotton/PET from the sliding on wool.

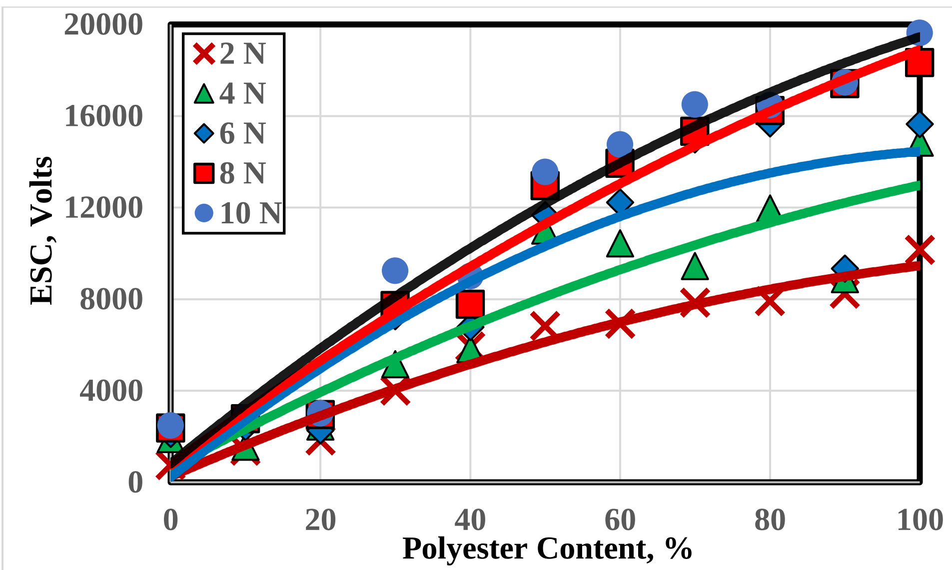


Fig. 7 ESC generated on the surface of wool from the sliding on cotton/PET.

The distribution of ESC on the contact surface after contact-separation and sliding is illustrated in Fig. 8. Cotton/PET gaines negative charge after rubbing wool, while wool gains positive ESC. The presence of CF facilitates the charge transfer from one surface to the other. The resultant ESC generated on the two surfaces depends on the CF content. It is clear that the intensity of ESC is influenced by the rank of the contact materials in the triboelectric series. Based on the tribo-electric series, the contact between cotton/PET and wool causes the object in the upper position of the series to

be positively charged (wool) and that in the lower position to be negatively charged (cotton/PET). In addition, the intensity of ESC of different polarity increases the electric field generated from the double layers of ESC as well as the attraction between the two contacting surfaces.

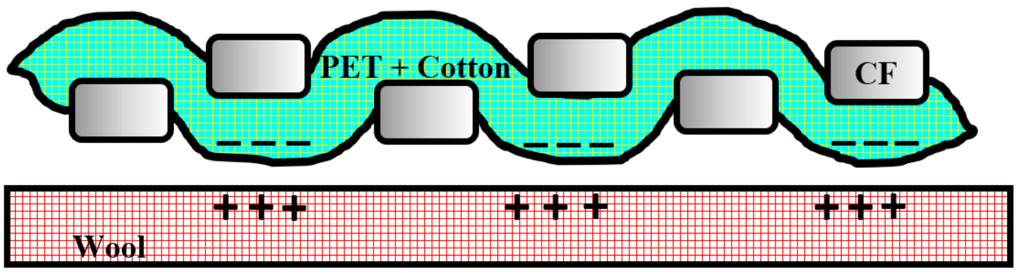


Fig. 8 Representation of ESC generated on the contact surfaces; after contact-separation and sliding.

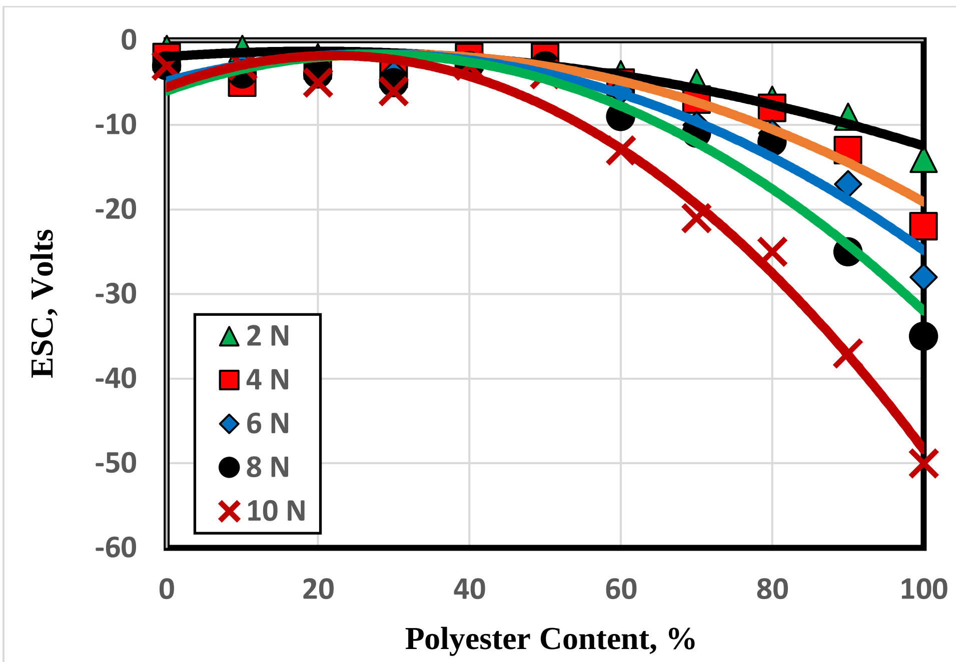


Fig. 9 ESC generated on the surface of cotton/PET blended by carbon fibers from the contact-separation with wool.

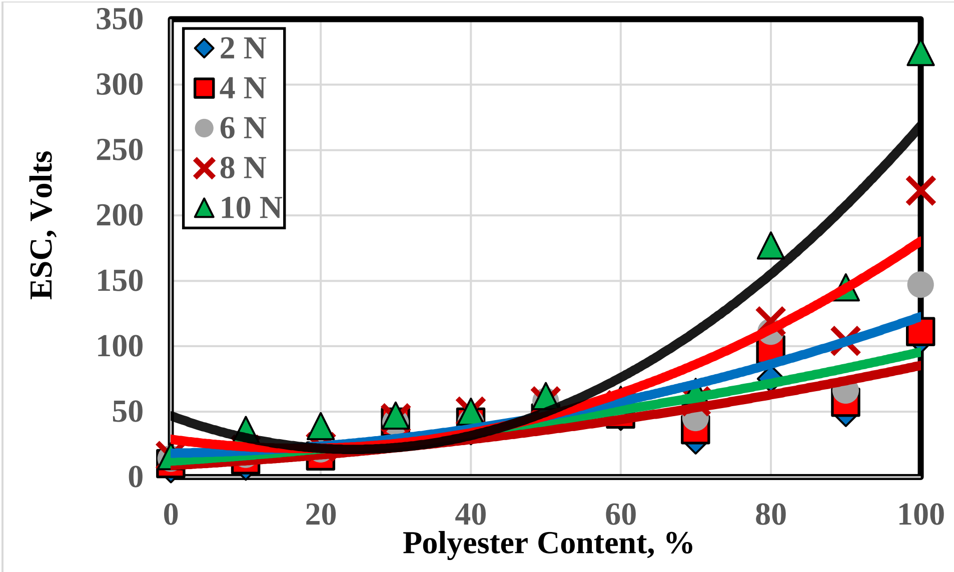


Fig. 10 ESC generated on the surface of wool from the contact-separation with cotton/PET blended by carbon fibers.

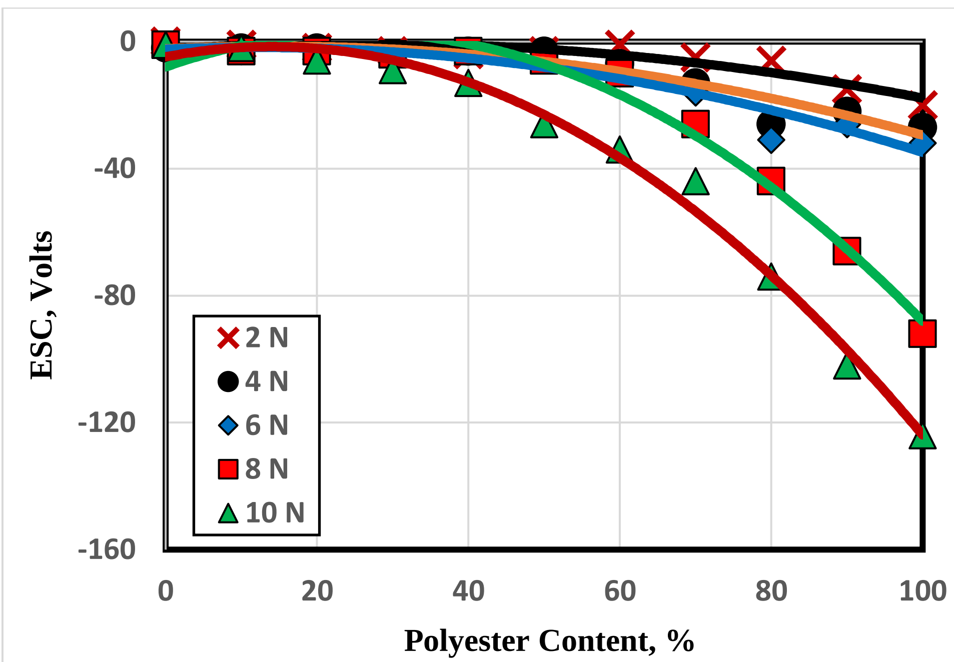


Fig. 11 ESC generated on the surface of cotton/PET blended by carbon fibers from the sliding on wool.

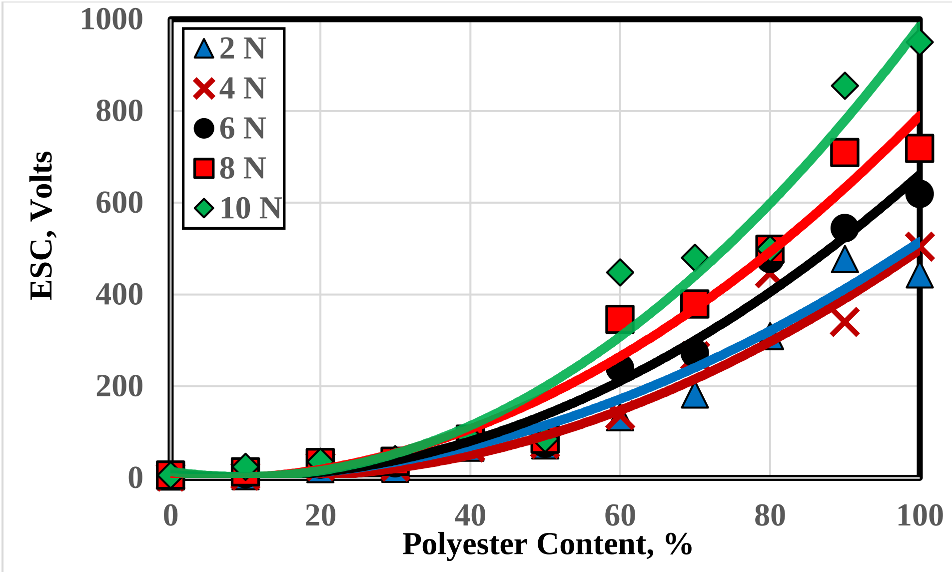


Fig. 12 ESC generated on the surface of wool from the contact-separation the sliding on cotton/PET blended by carbon fibers.

The results of experiments measuring ESC generated from the contact-separation of cotton/PET strings blended by carbon fibers with wool are illustrated in Fig. 9, where the negative values of ESC recorded -14, -22, -28, -35 and -50 volts at 2, 4, 6, 8 and 10 N load for 100 wt. % PET. The drastic decrease of ESC compared to that observed in strings free of CF is attributed to the easy charge transfer offered by the CF. While ESC generated on the surface of wool fibers is shown in Fig. 10, where the highest value (325 volts) was represented by sliding of 100 wt. % PET on wool. Based on that results it is seen that the effect of CF was significant.

Sliding of the cotton/PET strings blended by CF against wool displayed relatively higher vales than that observed in contact and separation, Fig. 11. The maximum values were displayed by 100 % PET (-124 volts), while ESC generated on the wool surface from sliding on the tested blend recorded 950 volts at 100 % PET, Fig. 12. The results showed that addition of CF remarkably decreased ESC and consequently the proposed composites will become environmentally safe textile materials.

CONCLUSIONS

1. ESC generated on the surface of cotton/PET from the contact-separation with wool showed relatively higher negative values that increased with increasing PET content.
2. The positive sign of ESC generated on the wool surface remarkably decreased with increasing PET content.
3. The positive sign of ESC generated on the wool surface remarkably increased with increasing PET content.
4. ESC generated on the surface of wool from the sliding on cotton/PET displayed remarkable increase of positive values.
5. Addition of CF remarkably decreased ESC and consequently the proposed composites will become environmentally safe textile materials.

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