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REDUCING THE ELECTROSTATIC CHARGE GENERATED FROM SLIDING OF RUBBER ON POLYETHYLENE ARTIFICIAL TURF

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ABSTRACT
Artificial football turfs are growing more popular as they offer a cheaper and carefree alternative for natural football turfs. The major drawback of the artificial turf is the high amount of electrostatic charge (ESC) generated from polyethylene (PE) artificial turfs that could have multiple negative effects on the quality of the turf and the safety of the players. The present study aims to reduce ESC generated by artificial turfs by blending PE fibers by polyurethane (PU) coated polypropylene (PP and PU coated PE) fibers. Besides, PE was blended by PU fibers and adhered to steel sheet film.

It was found that, it is possible to reduce the intensity of ESC generated on the surface of the material by blending it with another one of opposite charge. The proposed turf generates lower ESC compared to PE turf. The proposal of adding PP fibers coated by PU reduced ESC generated by artificial turf. Coating 80% of the PE fibers in artificial turf seems to reduce significantly the ESC. Finally, blending PE turf by PU fibers can be recommended to be used instead of the PE turf to decrease ESC.

KEYWORDS
Electrostatic charge, contact and separation, sliding, rubber, polyethylene, polyurethane, artificial turf.

INTRODUCTION
It is common known that when two different materials contacteach other, ESC is generated on both materials, this phenomenon is known as triboelectrification, [1 - 4]. The intensity of ESC generated on both materials depends on their position in the triboelectric series, [5 - 7], where the higher the material is in the triboelectric series, the more likely it is to gain a positive ESC when it contacts other material.

Triboelectrification causes fires, [8 - 10], increases the possibility of developing cancer, [11], and damages sensitive electronics, [12 - 15]. It is necessary to lower the intensity of the generated ESC to the lowest level. One of the approaches done to limit the intensity of ESC is to blend by materials that are on opposite sides of the triboelectric series to create a neutral blend, [16, 17].

PE is a very versatile plastic that is used in multiple uses, from making plastic bags to more modern uses such as composites, [18]. It is located in the lower (negative) part of the triboelectric series, [19]. PP is also an interesting material with many uses especially in the medical field, [20]. PP is close to PE in the tribolectric series. PU is another plastic that is more commonly used as a resin. It is located in the upper (positive) part of the triboelectric series. Artificial football turfs are commonly made of polymers like PE, [21, 22], which due to the high ESC generated by PE, [23, 24], can have a negative effect on the players.

The present study aims to investigate the effect of blending PE fibers by PU coated PP, PU coated PE fibers and PU fibers on the generation of ESC when rubber contacts and slides on the proposed fibers.

EXPERIMENTAL

The test specimens are classified into four groups. The first is the PE turf, Fig. 1. The second is PE turf (2 mm wide) blended by PU coated PP (4mm wide) fibers, Fig. 2. The third one is PE blended by PU coated PE, Fig. 3. The three test specimens are flattened on wooden block of 100 × 100 × 20 mm^3. The forth test specimen contains PE and PU of 4 mm wide fibers adhered to steel sheet, Fig. 4. The conventional PE turf is shown in Fig. 5. The contact and separation as well as sliding tests were carried out by pressing rubber sheet of 40 × 40 mm^2 and 3 mm thickness of 60 Shore A. The proposed fibers were tested under applied load of 17.5 N. The rubber was pulled manually to move 50 mm horizontally at dry sliding conditions. Each test was repeated 5 times and the average ESC was considered, where ESC was measured by an ESC voltmeter (AlphaLab inc. Surface DC Voltmeter SVM2) held at distance of 25 mm away from the surface of the specimen. The details of the test rig used in the experiment is shown in Fig. 6.

Fig. 1 PE turf.

Fig. 2 PE blended by PU coated PP turf.

Fig. 3 PE coated by PU.

Fig. 4 PE blended by PU and adhered at steel sheet.

Fig. 5 Conventional PE turf.

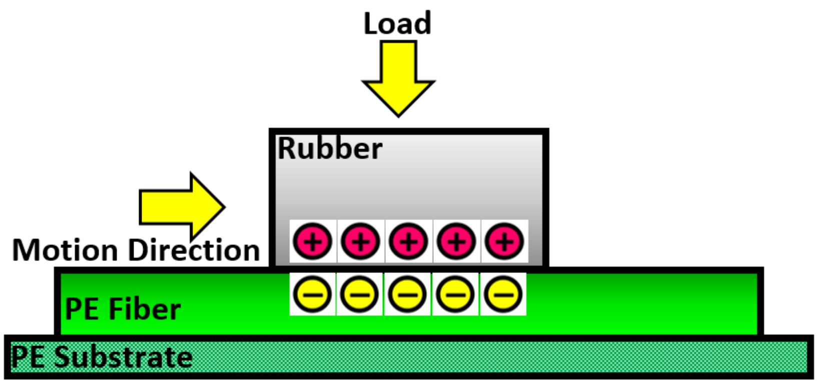

Fig. 6 Details of the test rig.

RESULTS AND DISCUSSION

Electrification of engineering materials influences their surface properties. When two surfaces of different materials contact each other, they may be charged. This phenomenon is called tribocharging or triboelectrification when materials rub each other, [25 - 27]. The charge transfer can be through electron and ion transfer as well as material transfer, [28 – 30]. Triboelectrification was attributed in metals to the electrons transfer from the metal to the counterface. In the triboelectric series the polymers are arranged in the order of their relative polarity. The higher positioned materials will gain positive charge when contact or rub material at lower position, [19]. It was found that the intensity of the generated ESC is dependent on the position of the material in the triboelectric series. Based on the triboelectric series, ESC increased when the ranking distance between the two contact surfaces increased.

It is well known that when two materials are in contact and are then separated the electrons from the two surfaces transfer, where one material gains electrons and the other loses electrons. Besides, friction and pressure cause generation of ESC. At contact and separation of rubber and the tested turf materials, PE turf gained negative ESC, while rubber gained positive one, Fig. 6. PU coated PP showed positive ESC due to the electrostatic properties of PU, while rubber gained negative ESC. This observation confirms the possibility of using PU as surface coating to decrease intensity of ESC. PU coated PE turf showed significant increase in ESC for both turf and rubber. It seems that the increase is due to the extra deformation of PE fibers so that the contact area increased during contact and separation.

After sliding, ESC generated from sliding of rubber on the tested turf materials recorded higher values for PE turf, Fig. 7. PE and rubber gained -2200 and 1300 volts respectively after sliding for 50 mm under 17.5 N applied load. PU coated PP showed drastic reduction in ESC, where the ESC showed 380 and -400 volts for turf and rubber respectively. PU coated PE showed remarkable ESC increase. Based on that observation it can recommended to coat the PP by PU to have ESC in the lower scale that can be allowed for application. That behavior can be explained on the bases of the triboelectric series, where PE and rubber are different materials so that the rubbing the two surfaces causes rubber in the upper position of the series to be positively charged and PE in the lower position to be negatively charged. Because PE is in the bottom of the triboelectric series so that the

long distance gives chance to exchange more electrons between rubber and PE. PU is closer to rubber than PE, therefore the ESC generated from contact and separation as well sliding of rubber on turf represented lower values.

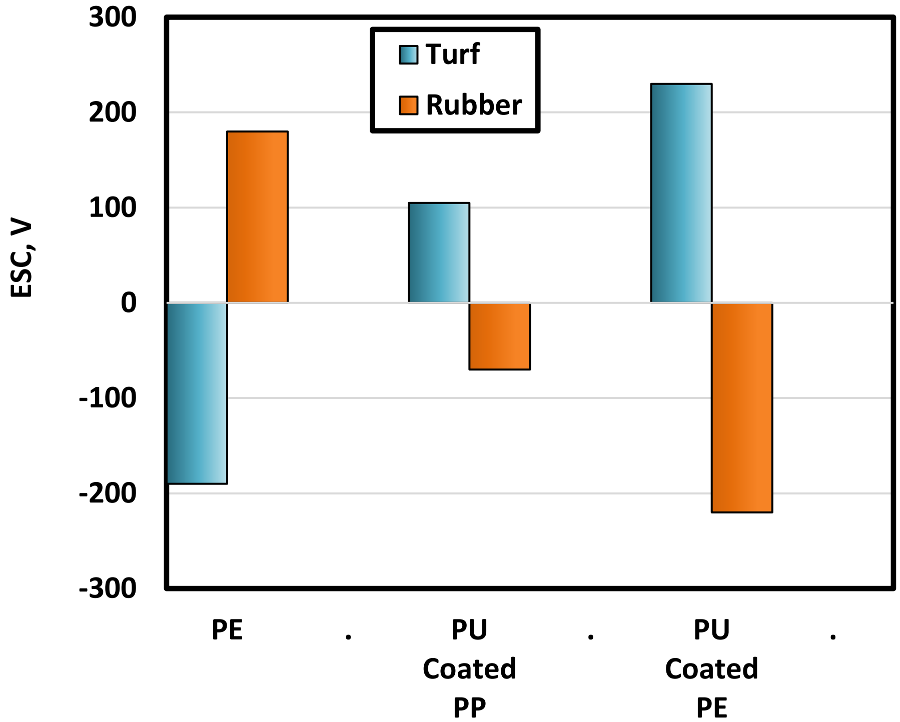

Fig. 6 ESC generated from contact and separation of rubber on the tested turf materials.

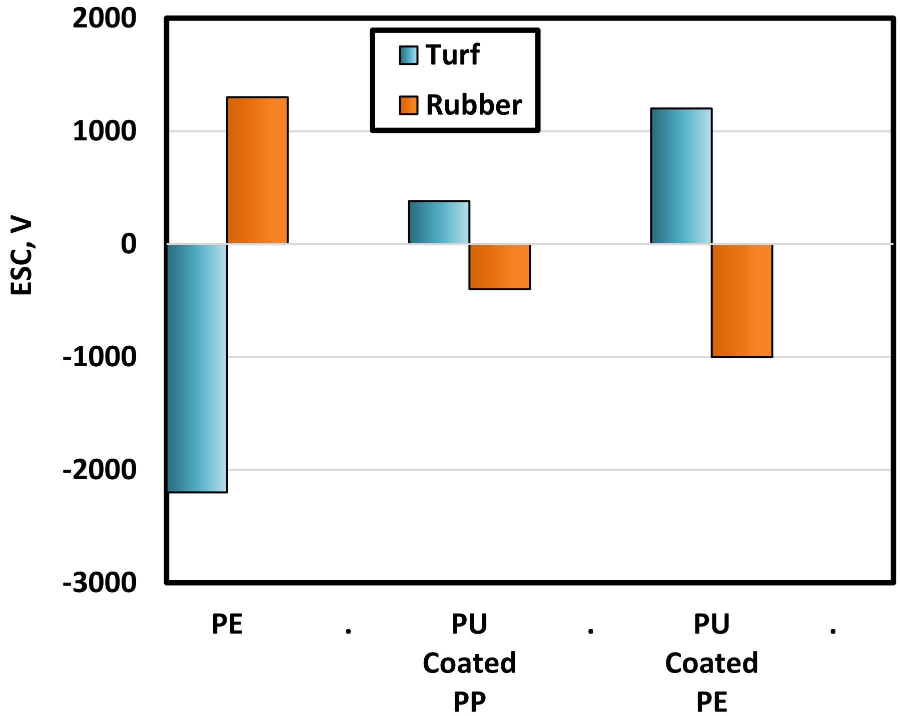

Fig. 7 ESC generated from sliding of rubber on the tested turf materials.

The reduction in the intensity of ESC can be explained on the bases of triboelectrification of the tested materials as shown in Figs. 8 and 9. PE rubbing rubber gained negative ESC due to the relative ranking in the triboelectric series, Fig. 9. While, PU coated PE gained positive ESC when rubbed rubber. This observation confirms that contact and separation as well as sliding of materials on each other should be accompanied by proper selection of the surface materials. Besides the severity of the generated ESC can be limited by using materials that are relatively closer to each other in the triboelectric series to generate lower ESC.

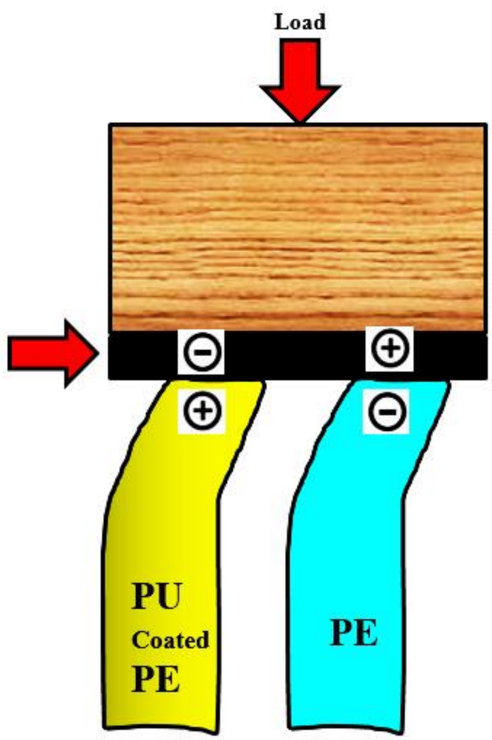

Fig. 8 Contact of rubber with PE and PP coated with PUR.

PU		**+ ESC**
Rubber		
PE		
PP		**- ESC**

Fig. 9 triboelectric series of the tested materials.

The results of experiments carried out to test PE turf blended by PU fibers and adhered to steel sheet are shown in Figs. 10 and 11. ESC generated from contact and separation of rubber on PU and PE turf materials is shown in Fig. 10. PU fibers displayed the highest

values of ESC generated on the surface of rubber and PU. Blending PU by PE showed drastic decrease in ESC, where its value decreased to minimum then increased with increasing PE fibers. Control of the intensity of ESC can be obtained by the blending process.

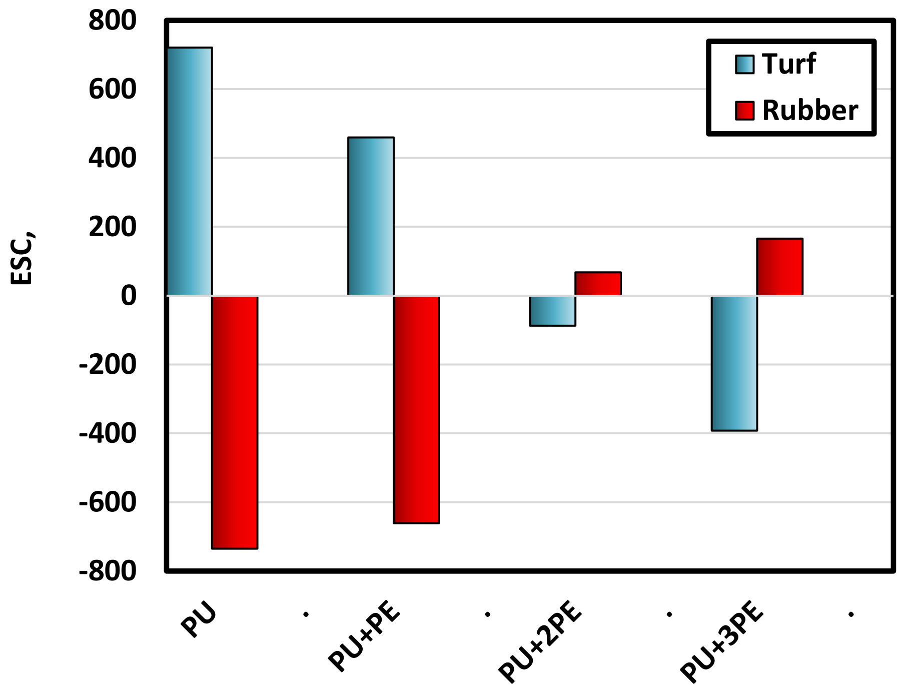

Fig. 10 ESC generated from contact and separation of rubber on PU and PE turf materials.

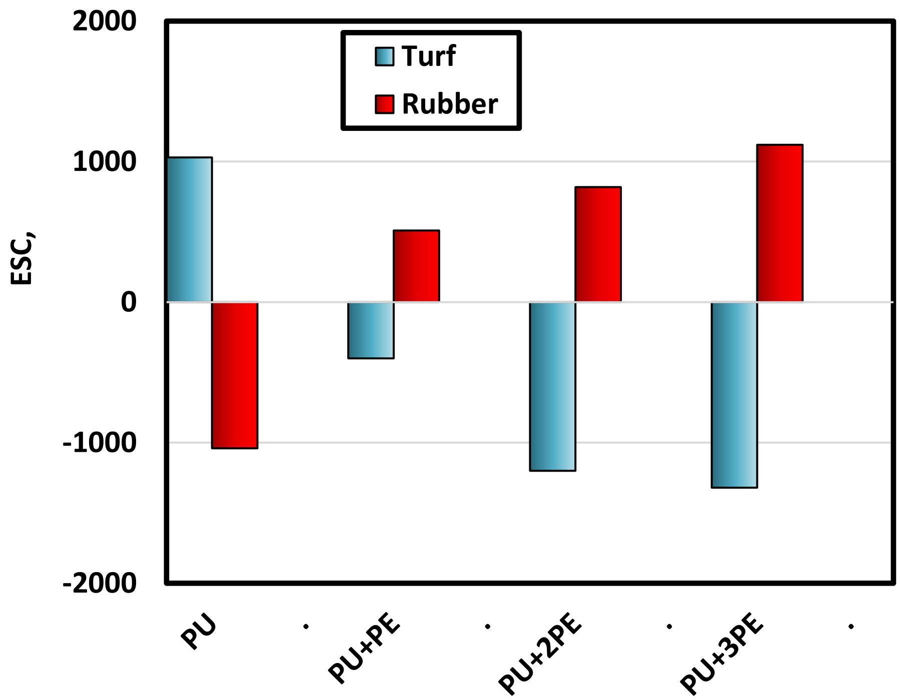

Fig. 11 ESC generated from sliding of rubber on PU and PE turf materials.

Sliding of rubber on the blend of PU and PE turf materials displayed relatively higher ESC than that observed in contact and separation, Fig. 11. It is clear from the figure that PE fibers were much affected by sliding than contact and separation, where the lowest values of ESC was observed for equal ratio of PE and PU. Besides, ESC showed higher values than that measured for contact and separation.

CONCLUSIONS

According to the above results, the followings can be concluded:

1. It is possible to reduce the intensity of ESC generated on a certain material by blending it with another one with an opposite polarity.

2. The charge generated in artificial turfs is too high and could have several bad effects.

3. The proposed turf generates lower ESC compared to PE turfs.

4. The proposal of adding PP fibers coated by PU reduced ESC generated by artificial turfs.

5. Coating 80% of PE fibers by PU in artificial turfs seems to reduce significantly the ESC.

6. Blending PE turf by PU fibers can be recommended to be used instead of PE turf to decrease ESC.

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