

## **ELECTROSTATIC CHARGE GENERATED FROM FABRICS SLIDING ON POLYMERIC MATERIALS**

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### **ABSTRACT**

The aim of the present work is to make use of the human biomechanical energy to harvest ESC generated from the contact and separation as well sliding of the fabrics of the cloths with each other. The generated ESC can be used as power supply for the personal medical sensors like thermometers, electrocardiograph, wearable watches and wireless radio-frequency communication system used in condition monitoring of the health of people. In the present study, the behavior of electrostatic charge (ESC) generated from sliding of high density polyethylene (HDPE) on polyester fabrics is investigated. In addition, the coefficient of friction is studied. The relation between coefficient of fraction and electrostatic charge is discussed.

The experiments revealed that as the weave size and the thickness of the strings increased friction coefficient and ESC decreased. This can be attributed to the fact that the number of fibers in contact with the counterface increased as the weave size and thickness of the strings decreased. This observation can be recommended for the manufacturer of the fabrics to control the strength of ESC of fabrics.

### **KEYWORDS**

Electrostatic charge (ESC), friction coefficient, HDPE, fabrics.

### **INTRODUCTION**

Harvesting renewable and green energy from ESC resources is of great need to compensate the consequences from fossil energy, [1]. Harvesting local energy is more efficient than constructing power plants of high cost and expensive infrastructure, [2, 3]. The conventional way to provide power for the electronics is to install batteries that have limited life. The replacement, management, and recycling of the huge number of batteries can represent high challenge, [2, 4, 5].

The triboelectrification can result from contact and separation as well as sliding, [6, 7]. Materials are electrostatically charged after contact and sliding on each other, where the strength of the charges depend on the rank of the materials in the triboelectric series, [8 - 12]. Materials are ranked in the triboelectric series due to their ability to gain or lose electrons depending on their physical property. Generally, the build-up of ESC would

result in failure of electronic appliances. Triboelectric series can be applied to select materials of certain value of ESC. Moreover, there are some practical applications. On the other hand, triboelectrification has found extensive interest to fabricate triboelectric nanogenerators (TENGs), that can be used for converting friction into ESC for energy harvesters, [13].

The increase use of energy-harvesting textiles has received intensive attention due to their applications in wearable smart electronics. The blend of steel wire and polyester fibers coated by energy harvesting material generated ESC from textile and worked as nanogenerator (TENG). The collected ESC can light up a warning indicator, charging a capacitor, and provide energy for smart device. It was found that a smart blanket was designed to convert body movement and biomechanical energy into energy,[5].

The present work, ESC generated from sliding of high density polyethylene (HDPE) on polyester fabrics of different weave size and string thickness is investigated. Besides, the coefficient of friction is studied.

### EXPERIMENTAL

The test rig shown in Fig. 1 is used to measure coefficient of friction (COF) by using the load cell output. The output of the load cell signal was calibrated with normal load by Arduino program to determine the coefficient of friction, Fig. 3. Moreover, ESC in mV was measured by Arduino as shown in wiring diagram, Fig. 4. In addition, the vice is used to control the movement of fabrics in perpendicular direction of the normal force as illustrated, Fig. 1, back and forth. However, using of two copper plates is essential to measure the output values of ESC. The fabrics were chosen in different polyesters weaves (A, B, C, D and E), Fig. 5. The normal load was 2, 4, 6, 8 and 10 N.

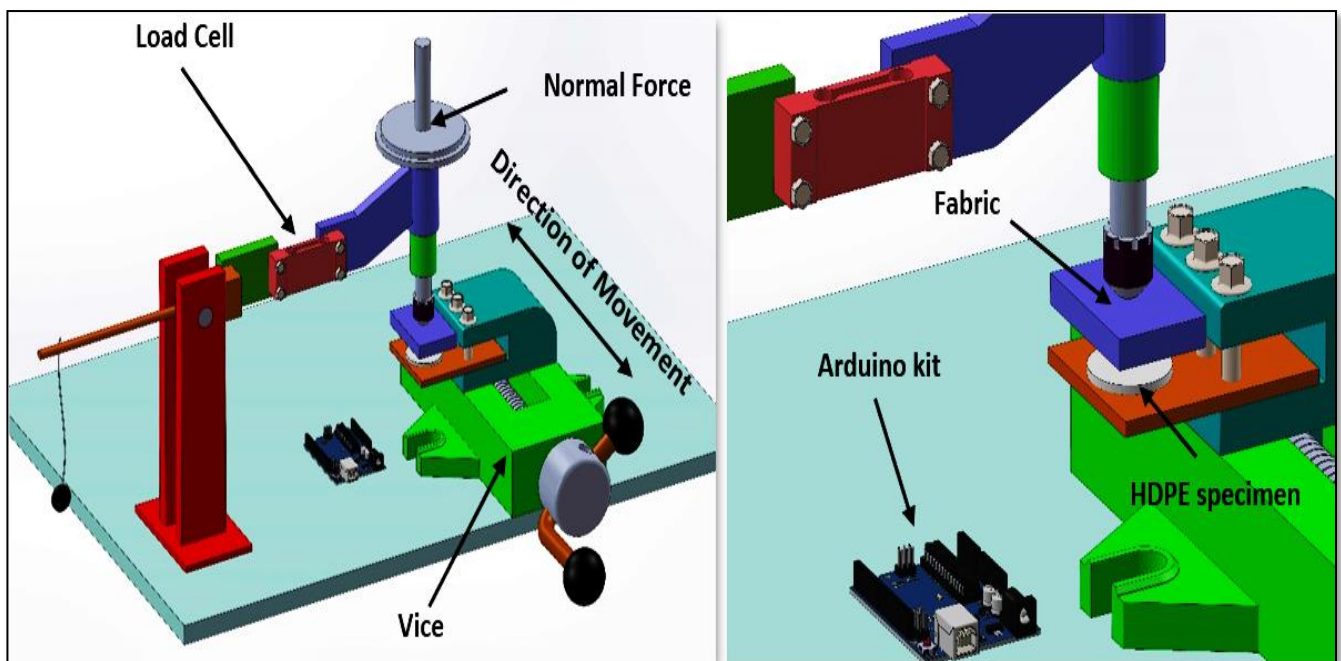
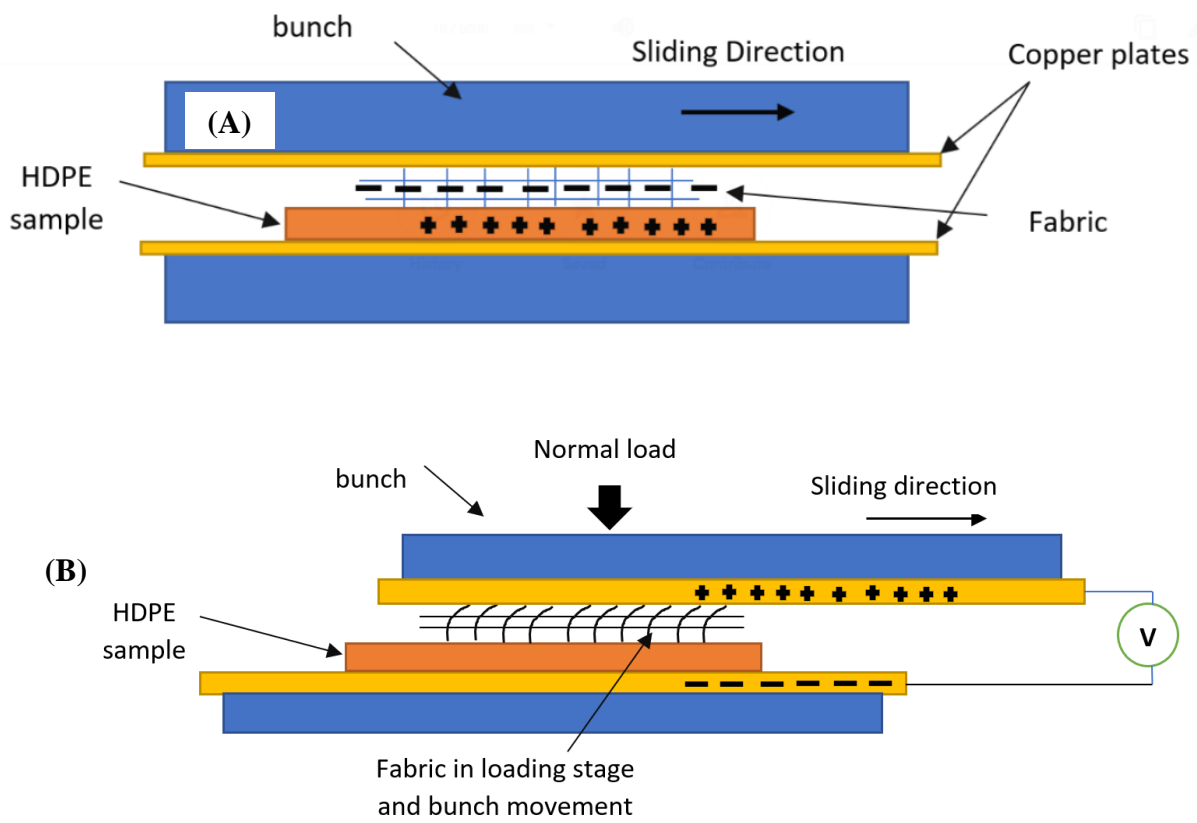
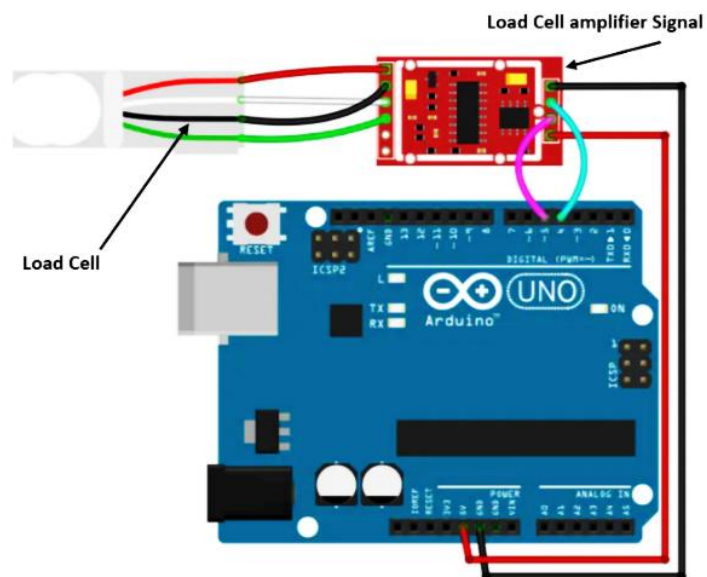


Fig. 1 Test rig for measuring electrostatic charge and coefficient of friction.



**Fig. 2 Illustration of the ESC generated from sliding.**



**Fig. 3 Wiring diagram for load cell signal.**

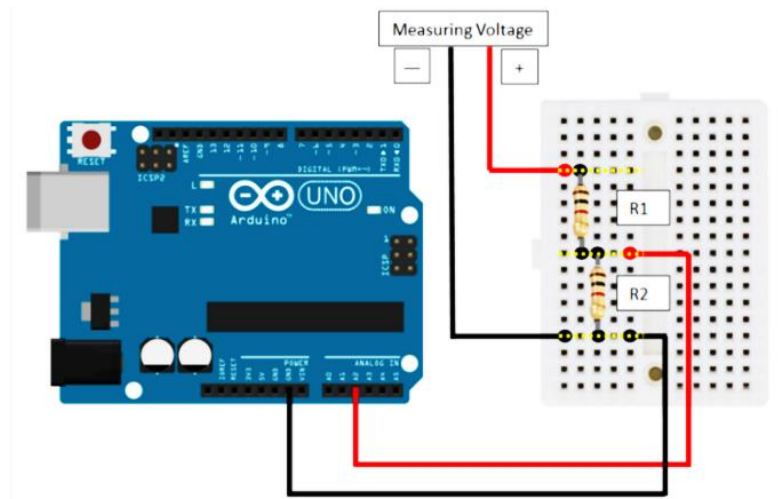


Fig. 4 Wiring diagram of Arduino kit for DC volt measurement.

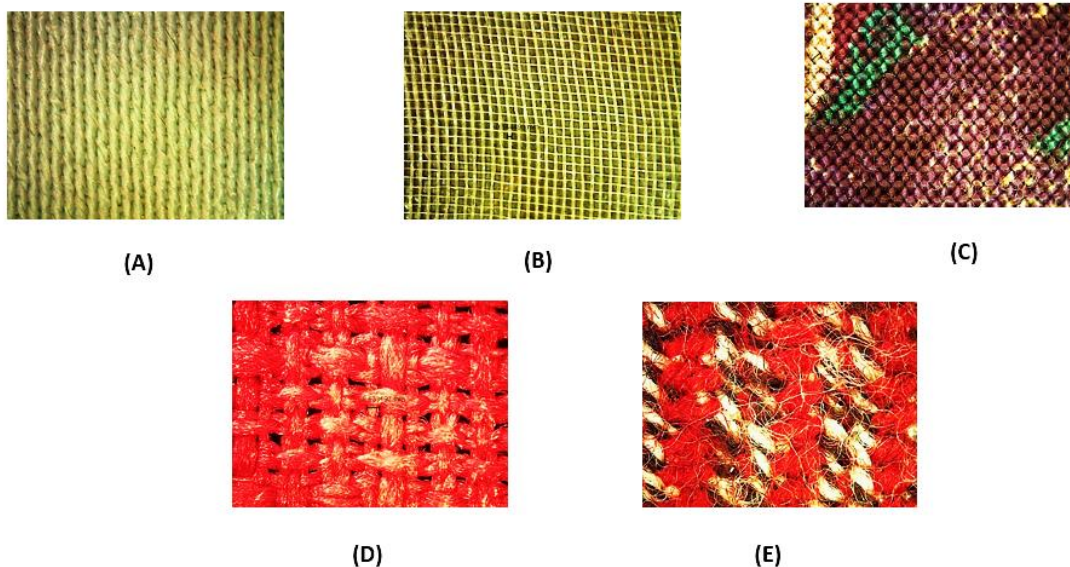


Fig. 5 Microphotographs of the tested fabrics.

## RESULTS AND DISCUSSION

The coefficient of friction plays a major role in the tribological properties. Coefficient of friction (COF) is a dimensionless number and defined as the ratio between friction force and normal force. COF depends on the nature of the materials and surface roughness in both material sides. The normal force in this test is equal to the gravity force of the weight.

Coefficient of friction drastically decreased with increasing the normal force, Fig. 6. It was observed that the type of fabrics influenced the friction values, whereas the weave size and the thickness of the strings increased, friction coefficient decreased. It seems the number of fibers in contact with the counterface increased as the weave size and thickness of the strings decreased. Fabric (A) represented the highest friction values, while fabric (E) showed the lowest values. The friction decrease with increasing the normal force may be explained on the bases that the load is ironing the fabrics, Fig. 7, and consequently the friction of the fibers drastically reduced.

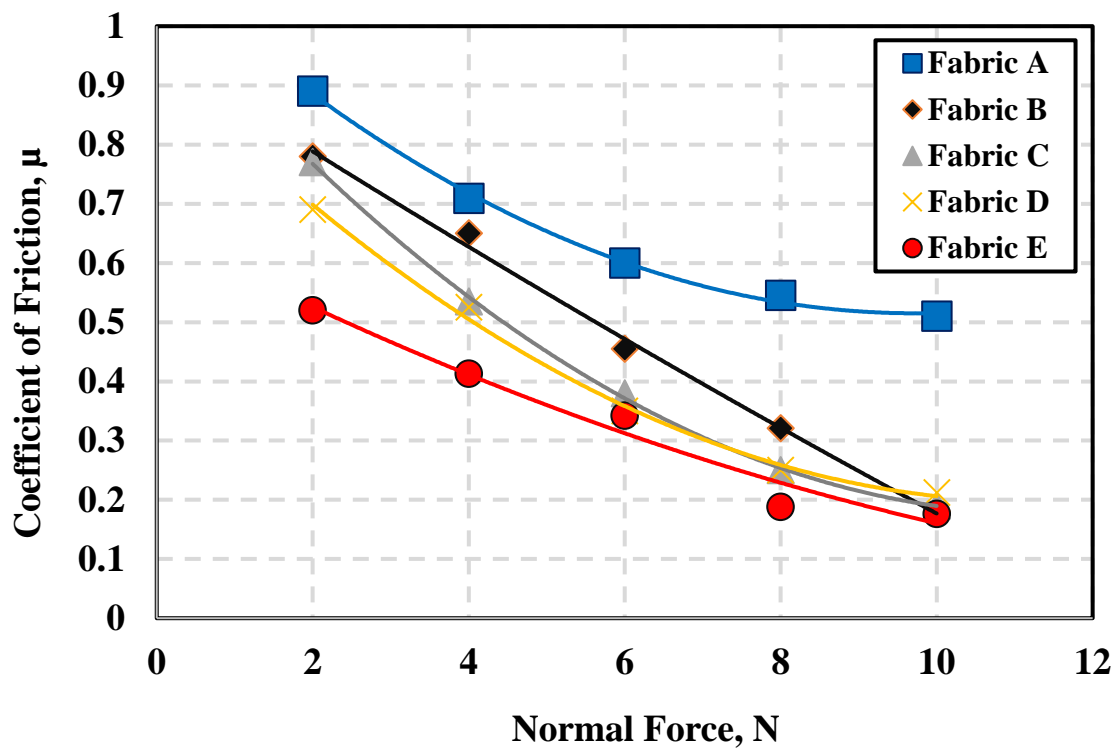


Fig. 6 The relation between normal load and coefficient of friction for different fabrics.

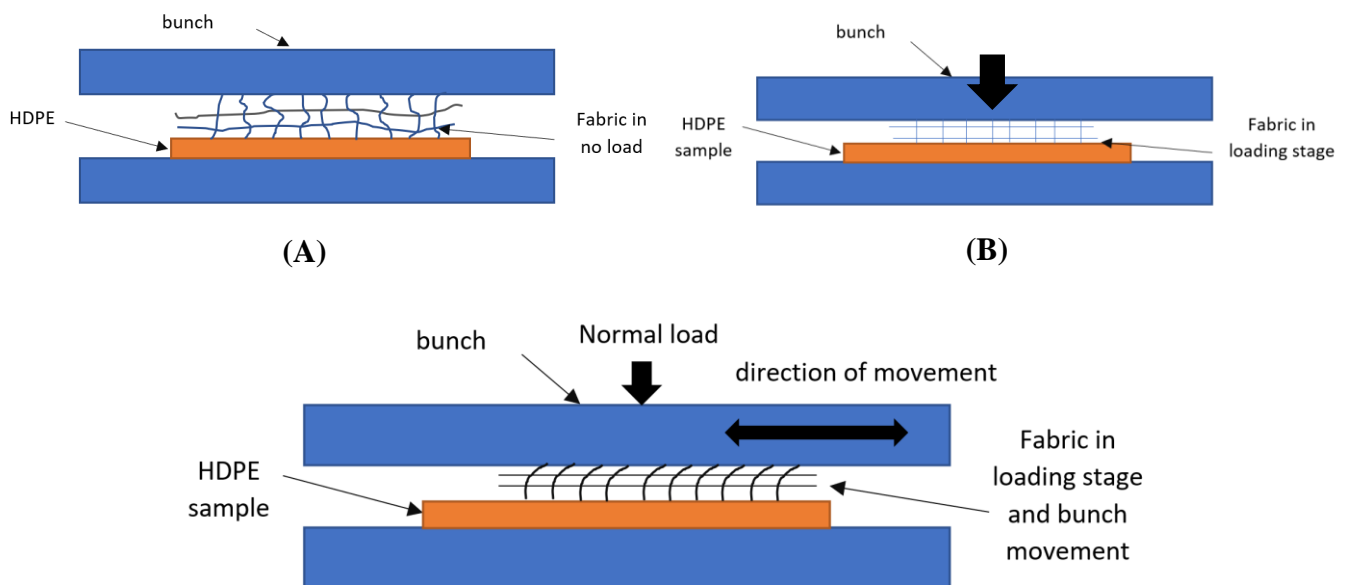


Fig. 7 Illustration of fabric interact in loading stage (A) no load, (B) in normal load stage & (C) full load.

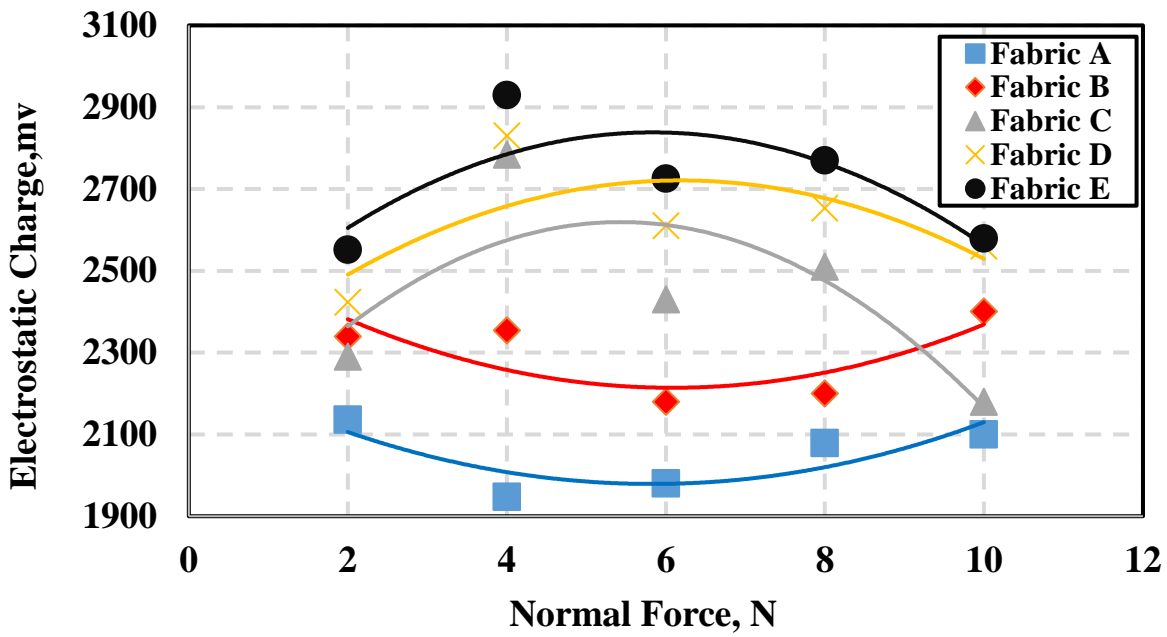


Fig. 8 The relation between normal load and electrostatic charge for different fabrics

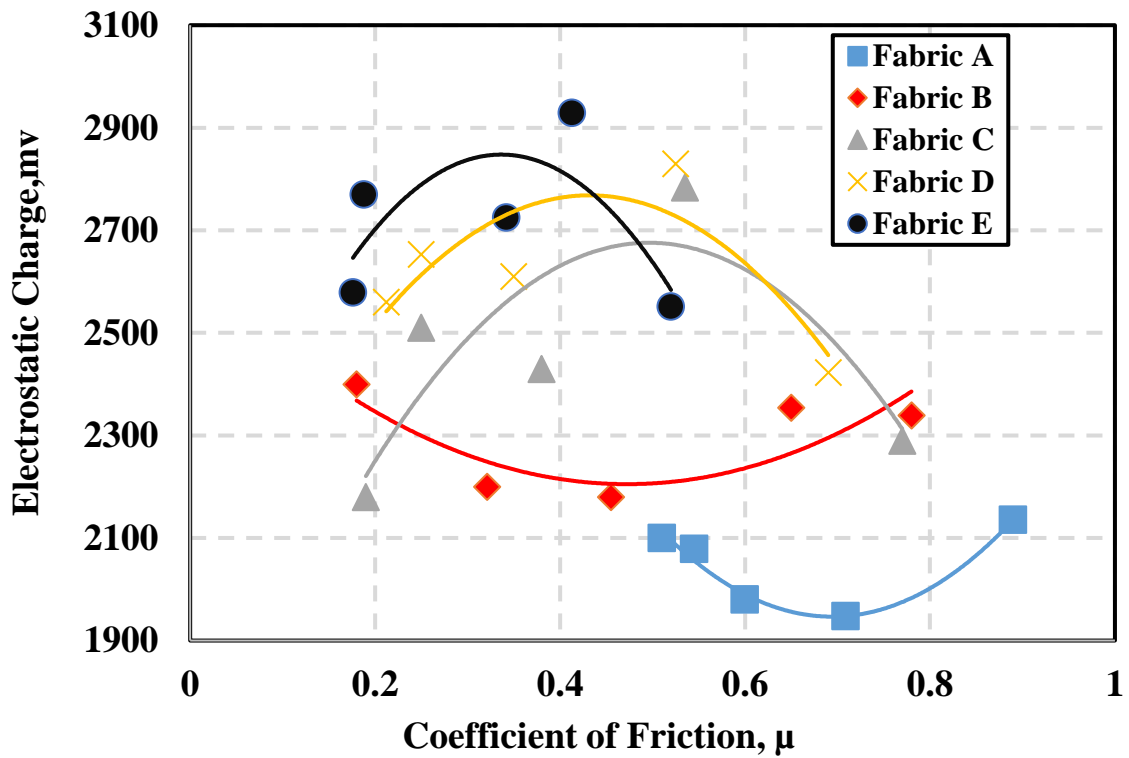


Fig. 9 the relation between electrostatic charge and coefficient of friction.

Figure 8 describes the relation between ESC and normal load. It is clearly observed that some of the tested fibers showed an increase in ESC up to maximum then decreased with increasing the normal load. While the others decreased down to minimum then slightly increased with increasing load. It is observed that the values of ESC recorded significant variance for the fabrics. The values of ESC increased as the weave size increased. The explanation of that behavior depends on the fact that the number of contacting fibers increased with decreasing both the weave size and string thickness as discussed in Fig. 6. This conclusion can be recommended for the manufacturer of the fabrics to control the strength of ESC of fabrics.

The recorded values for ESC versus coefficient of friction at different normal load for the tested fabrics is represented in Fig. 9. It can be observed that fabric (E) showed the highest ESC values up to 2900 mV at 0.55 COF, while fabric (A) displayed the lowest ESC compared to other tested fabrics. COF for (A) reached to 0.89.

## CONCLUSIONS

From the present investigation, it can be concluded the followings:

1. Coefficient of friction decreases with increasing the normal force due to ironing of the fabrics.
2. Values of ESC recorded significant variation for the tested fabrics. The values of ESC increased as the weave size increased.
3. ESC and COF decreased as the weave size and the thickness of the strings increased. This observation can be recommended for the manufacturer of the fabrics and TENGs to control the strength of ESC of fabrics.

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