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PROPER SELECTION OF FLOOR MATERIALS IN HOSPITALS

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ABSTRACT

Friction of engineering materials generates electrostatic charges (ESC) that have a negative effect on the environment. The increased use of polymeric materials raised the importance of studying that effect. ESC building up on human skin and or clothes in direct contact with human body are very harmful and can create serious health problems. The present study investigates the ESC generated from the dry and water wet sliding of shoes on floor for people who are working in hospitals.

The present work revealed that epoxy and PVC tiles displayed the highest friction coefficient values. Besides, they gained the lowest ESC values. PVC gained lower ESC than epoxy. At sliding, ESC generated on the surface of, Fig. 5, ESC showed much higher values than that measured for contact/separation. While contact/separation of water wet epoxy increased ESC compared to dry contact. Sliding of shoe cover against dry epoxy recorded higher ESC values than PVC. It is recommended to apply epoxy floor than PVC to guarantee that the floor gains positive charge to attract the viruses.

KEYWORDS

Floor materials, hospitals, electrostatic charges, polypropylene, polyethylene.

INTRODUCTION

The equipment of medical care workers such as uniform and shoes are made of polymers that generate ESC due to the friction with other surfaces. The equipment of medical care workers such as uniform and shoes are made of polymers that generate ESC due to the friction with other surfaces. They are easily triboelectrified. Epoxy and polyvinyl chloride (PVC) are widely applied as floors in hospitals, [1]. To overcome the brittleness of epoxy, recycled rubber (butadiene-acrylonitrile) was added as filler in epoxy, [2 – 5], where rubber granulates developed the ductility and increased friction of epoxy, [6]. Recently, epoxy was filled paraffin oil to increase its toughness and the viscoelastic property, [7]. Besides, addition of rubber and oil drastically decreased ESC, [8]. It was found that epoxy composites filled by wood,

rice straw and palm fibers decreased ESC, [9 - 11]. ESC decreased with increasing the content of the tested fibers that fill epoxy matrix. It is necessary that the sign and magnitude of ESC in hospitals, [12], should be controlled. Shoes and shoe covers should be made of polypropylene (PP) polyethylene (PE) respectively to gain negative ESC and consequently repel the viruses away. The majority of viruses were reported to have negative charge, [13 - 16]. Based on that observation, epoxy floor was preferrable to be used instead of polyvinyl chloride (PVC) tiles so that the floor gains positive ESC and can attract the viruses of negative ESC, where cleaning and disinfection are available.

It was found that creeping and walking on floor generate ESC. Besides, ESC generated from foot wearing socks and bare foot sliding on rubber, marble, ceramic, moquette and parquet was measured, [17 - 22]. The dependency of friction coefficient on ESC was investigated, [23], where ESC controls friction coefficient, because increase of ESC develops the attraction and adhesion force between the two sliding surfaces leading to the increase of friction coefficient, [24]. It was found that filling epoxy by brass and copper particles displayed an increase of ESC, [25 - 27].

In addition to that, ESC built up on human skin represents harmful effect on health, [28]. ESC could be drastically decreased with increasing iron nanoparticles content filling epoxy. It was observed that bare foot sliding on epoxy floor generated lower ESC than that gained by rubber footwear as result of the good electrical conductivity of human body, [29]. Besides, ESC can affect adhesion and friction, [30], where ESC depends on the load, contact area and sliding distance.

The present work investigates ESC generated from the dry and wet sliding of shoe and shoe cover against two types of floors in hospitals.

EXPERIMENTAL

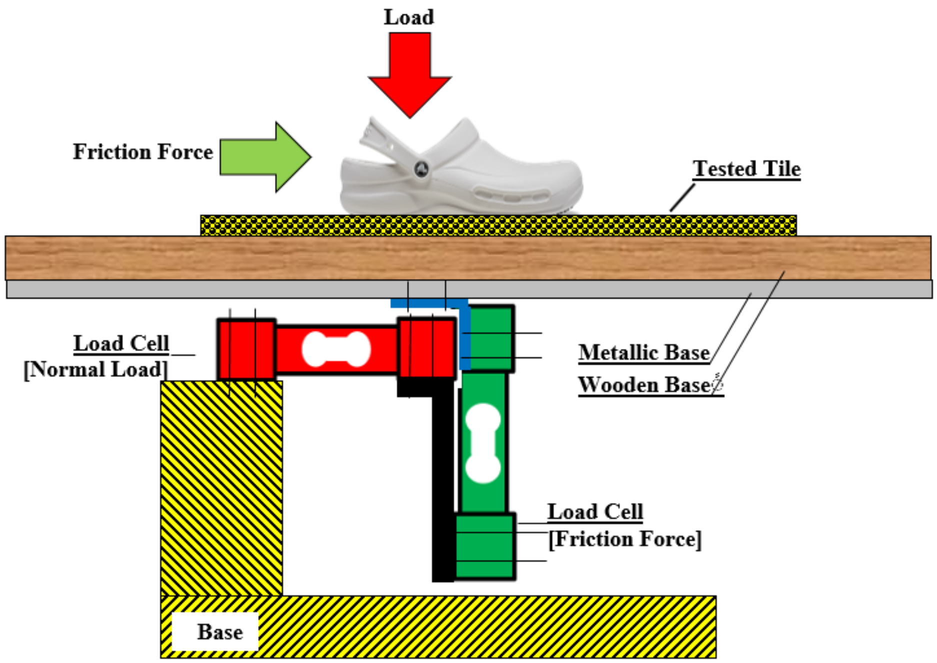

Fig. 1 The details of the test rig.

In the present experiments, friction coefficient displayed by the contact/separation and sliding of the tested PP shoe with and without PE cover on epoxy composites at dry and water wet conditions, Fig. 1.

The tested floor tiles were epoxy, PVC, marble, ceramic, parquet ceramic, flagstone and porcelain of 400 × 400 mm^2 of 5.0 mm thickness. The PP shoe was loaded into the tile at different load values. The tested tiles were adhered into the base of the test rig. Two load cells, the first measured the friction force while the second measured the normal load, were supporting the test rig base.

The tested tiles and shoe were cleaned with water to remove dirt before the tests. PP shoe was loaded by foot into the tested tile. The tests were carried at normal load varying from 0 to 900 N at dry and water wet contact condition. The readings of friction and ESC at 200, 600 and 900 N were considered in the analysis representing the behavior of kids, women and men respectively. ESC could be measured by Ultra Stable Surface DC Voltmeter. In contact/separation, load was applied for five seconds then ESC was measured on the surface of the tested tiles. After sliding of the shoes for 100 mm, ESC was measured.

RESULTS AND DISCUSSION

Increasing friction coefficient displayed by sliding the shoe on the floor can enhance safety of walking. Figure 2 shows the values of friction coefficient displayed by sliding of PP shoe on the tested floor. The highest friction coefficient values were displayed by epoxy and PVC tiles. That observation confirms the suitability of those materials tb applied as floor materials. PP shoe sliding on marble experienced the lowest friction coefficient. As the load increased, friction coefficient decreased. Parquet

ceramic and flagstone higher friction values than that observed for ceramic and marble. In the other side, porcelain showed lower friction values than that measured for ceramic and parquet ceramic, while higher than that displayed by marble.

ESC generated by dry sliding of PP shoe on the tested tiles, Fig. 3, increased with increasing the load due to the increase of the contact area that facilitated ESC transfer into the two contact surfaces. It was found that epoxy and PVC tiles gained the lowest ESC values. Voltage measured after sliding against porcelain tile displayed the highest values. The values were 4300, 5100 and 5400 volts for kids, women and men respectively. The increase of ESC with increasing normal load resembles big danger to people of heavy weight because ESC generated on the floor is accompanied by another one generated on the outer sole of the shoe. Based on that observation it should be suggested to carefully select floor materials according to their ability to generate ESC.

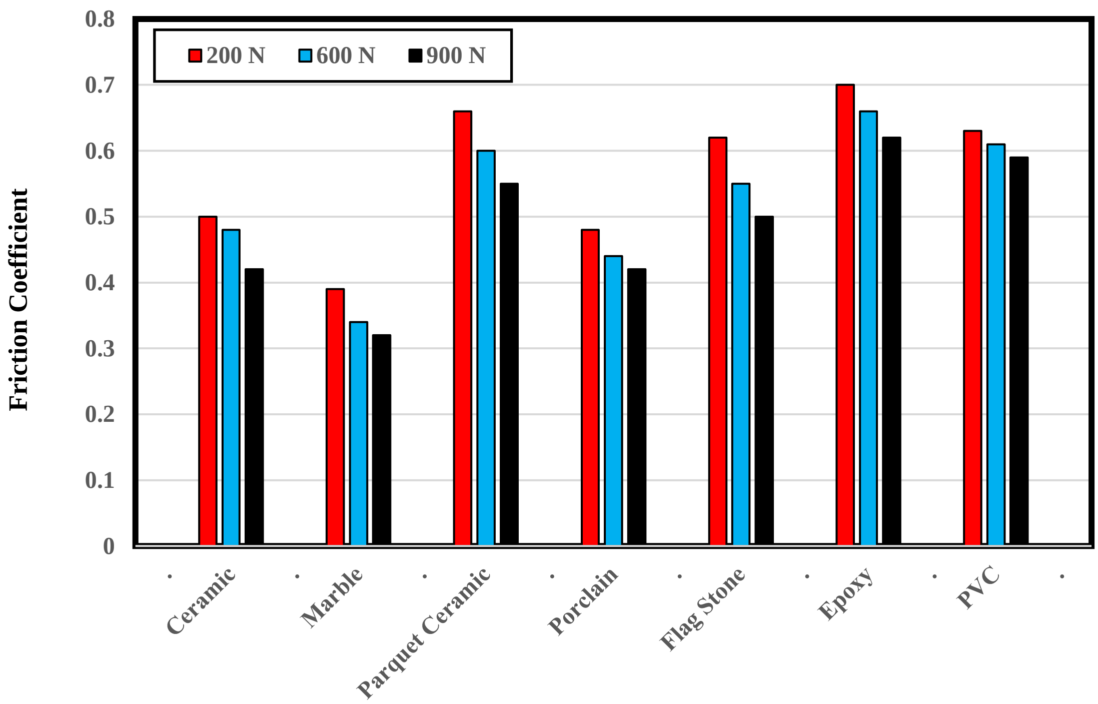

Fig. 2 Friction coefficient displayed by dry sliding of PP shoe and tested tiles.

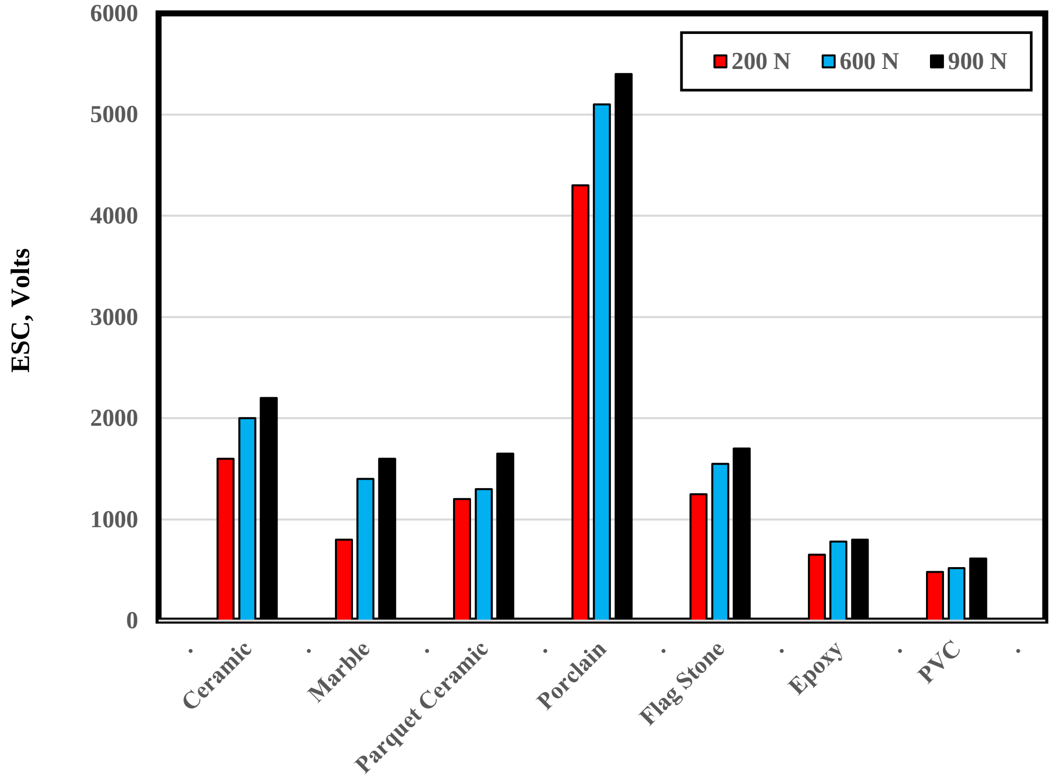

Fig. 3 ESC generated from dry sliding of PP shoe and tested tiles.

After examining the tested tiles, it was revealed that both epoxy and PVC tiles proved to be the best among the tested tiles. Further experiments were carried out to collect extra information about their ability to gain lower ESC values. At dry contact/separation of PP shoe and tested tiles, Fig. 4, ESC generated on the surface of PVC tiles were lower than that displayed by epoxy. At sliding, Fig. 5, ESC displayed much higher values than that measured for contact/separation, where the values reached 3100 volts for men.

The contact/separation of water wet epoxy experienced an increase in ESC values compared to that observed at dry contact, Fig. 6, where the highest recorded value was +1000 volts for epoxy while PVC acquired 220 volts. At sliding, Fig. 7, epoxy gained lower ESC than that observed at contact/separation. It seems that water film formed on the contact surfaces conducted the double layers of ESC of different signs from the tested tiles and PP sole.

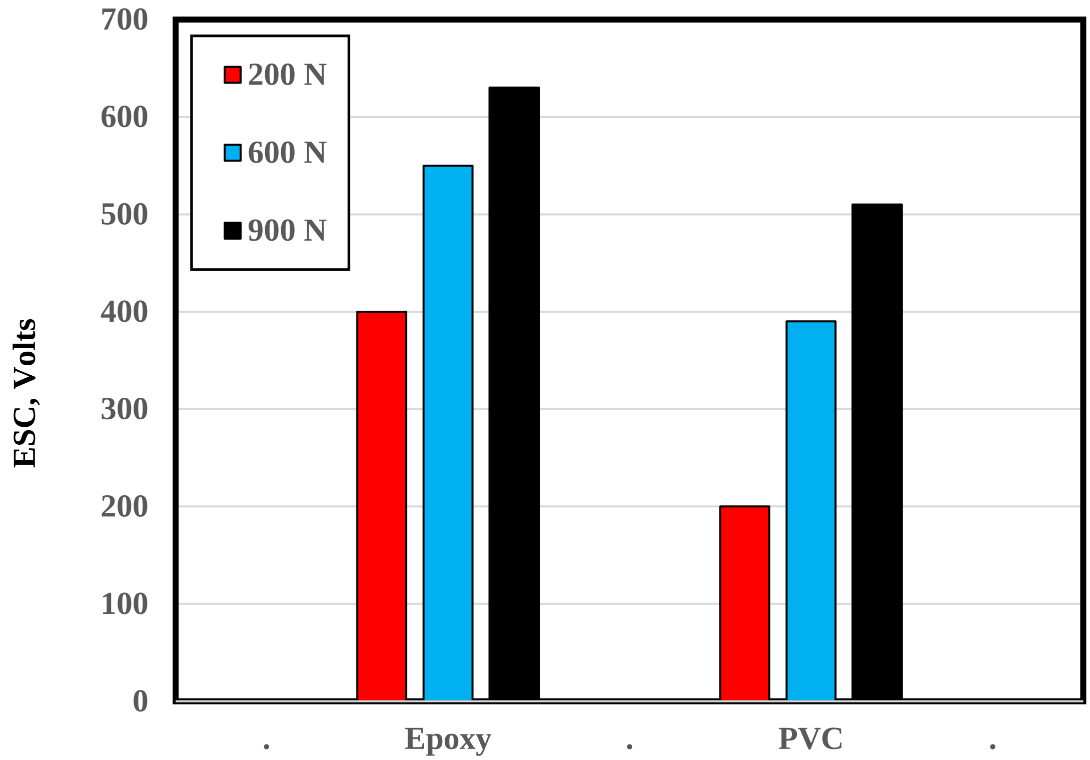

Fig. 4 ESC generated from dry contact/separation of PP shoe and tested tiles.

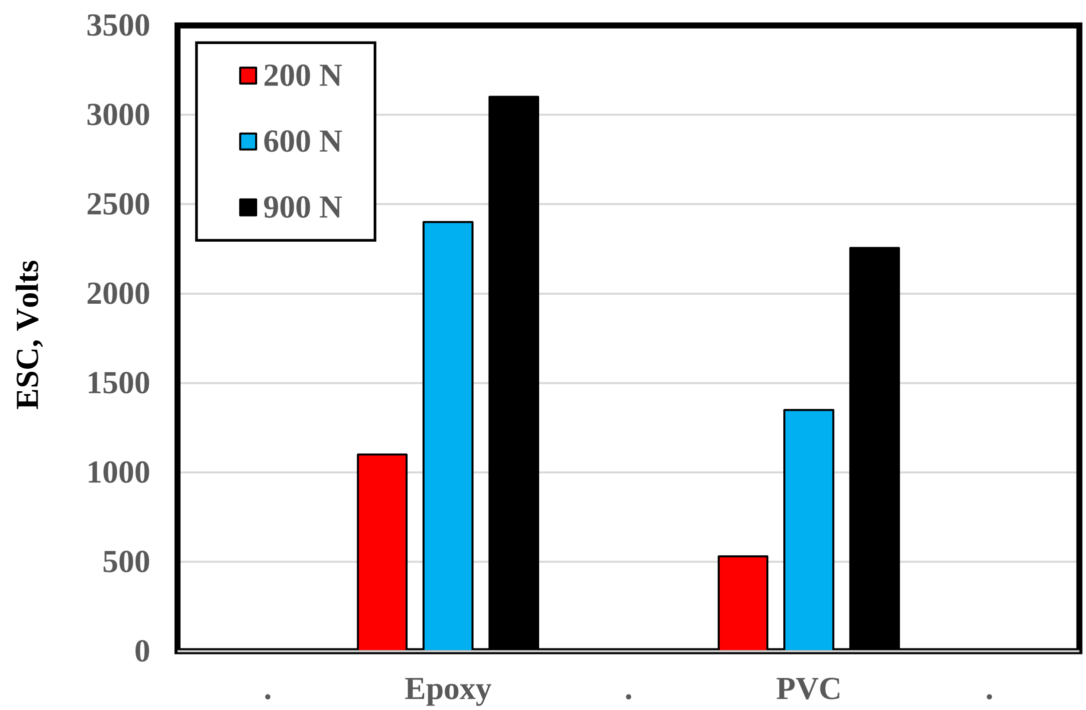

Fig. 5 ESC generated from dry sliding of PP shoe and tested tiles.

Figure 8 shows ESC generated from dry contact/separation of PE shoe cover and tested tiles, where epoxy gained 600 volts at 900 N, while PVC tiles gained 400 volts. Sliding of shoe cover against dry epoxy tile, Fig. 9, ESC recorded higher values of 1350 and 450 volts for epoxy and PVC tiles at 900 N load. It seems that the relatively higher values of ESC were from the friction of the PE cover and the tested tiles.

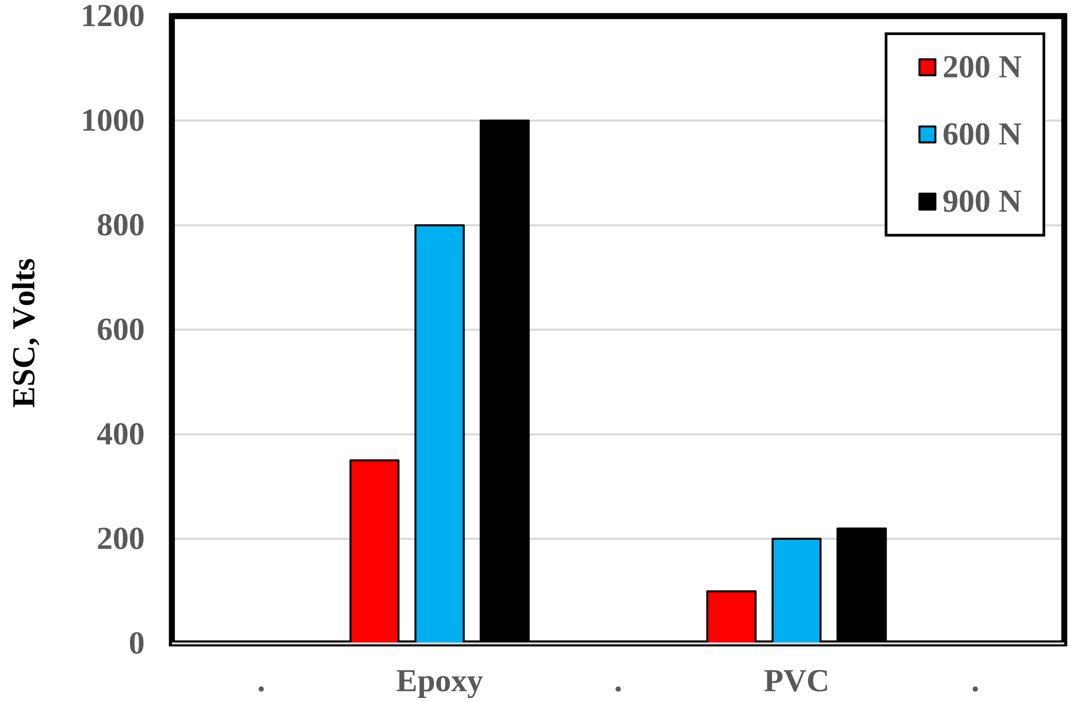

Fig. 6 ESC generated from water wet sliding of PP shoe and tested tiles.

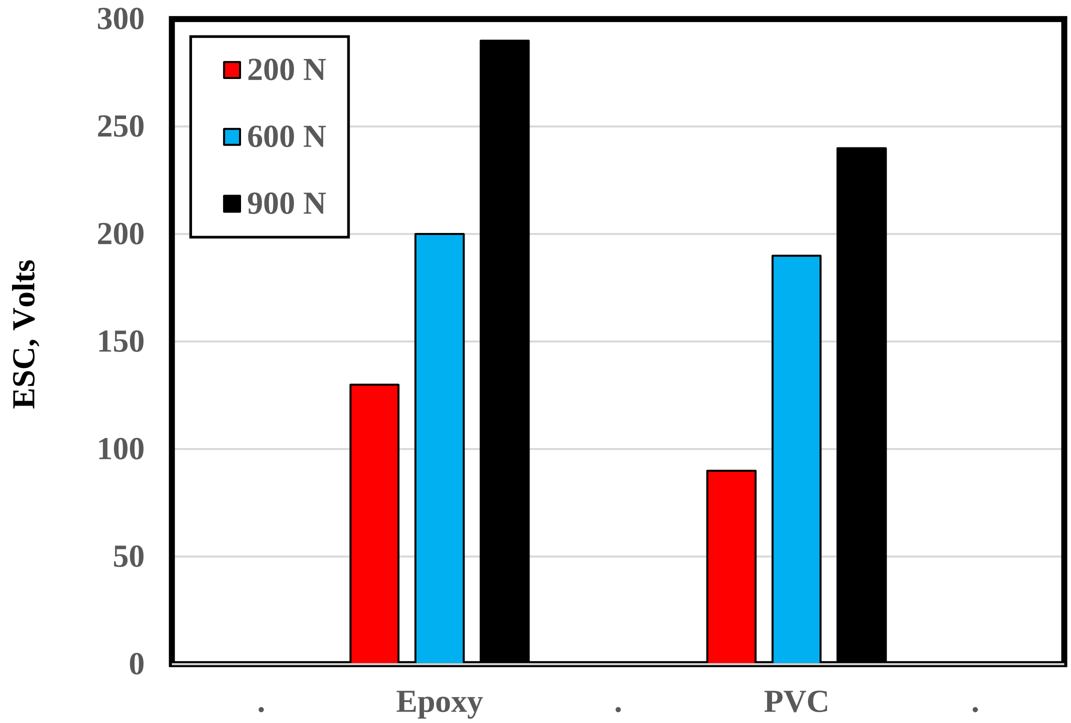

Fig. 7 ESC generated from water wet sliding of PE shoe and tested tiles.

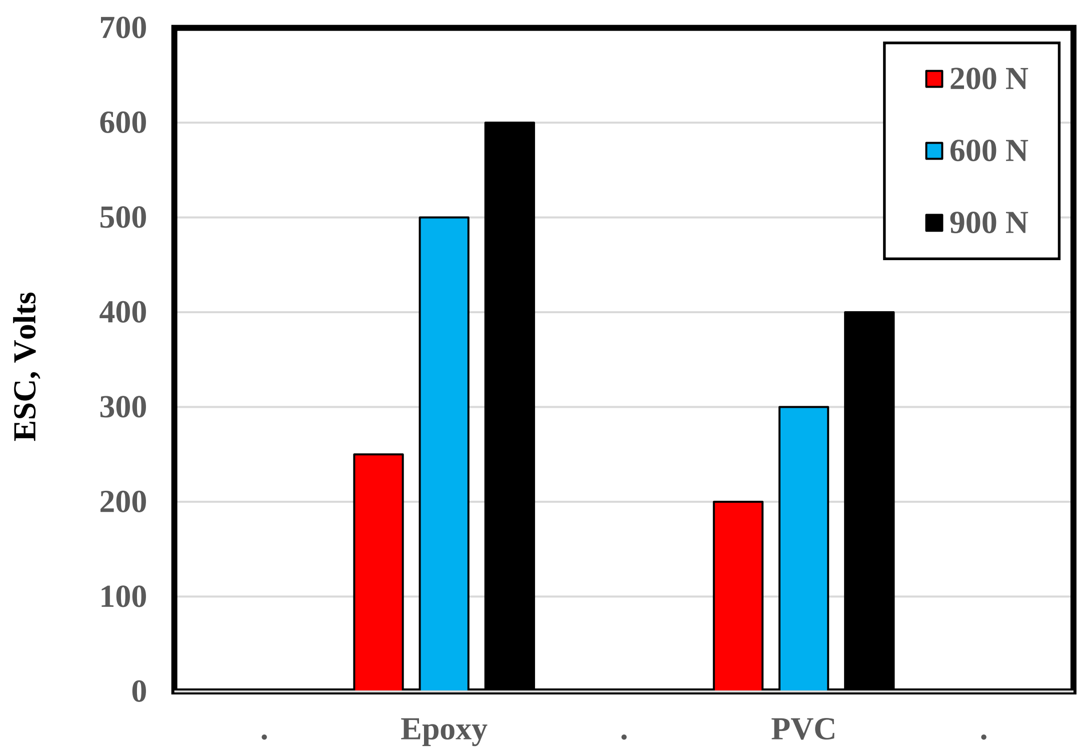

Fig. 8 ESC generated from dry contact/separation of PE shoe cover and tested tiles.

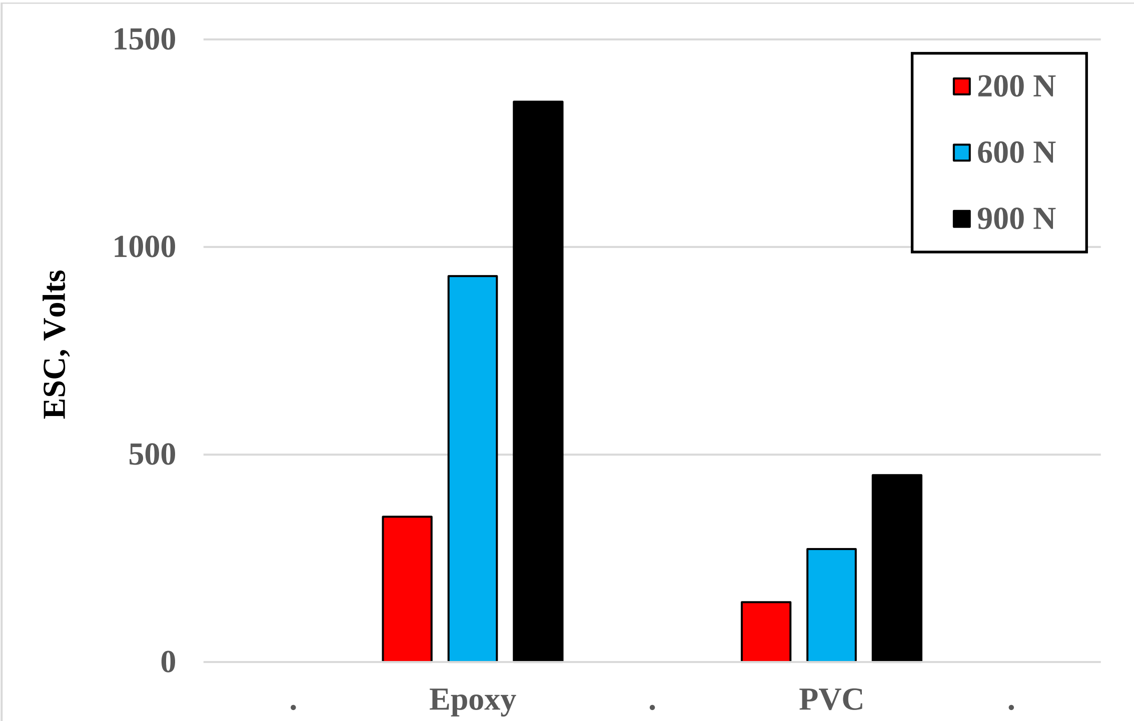

Fig. 9 ESC generated from dry sliding of PE shoe cover and tested tiles.

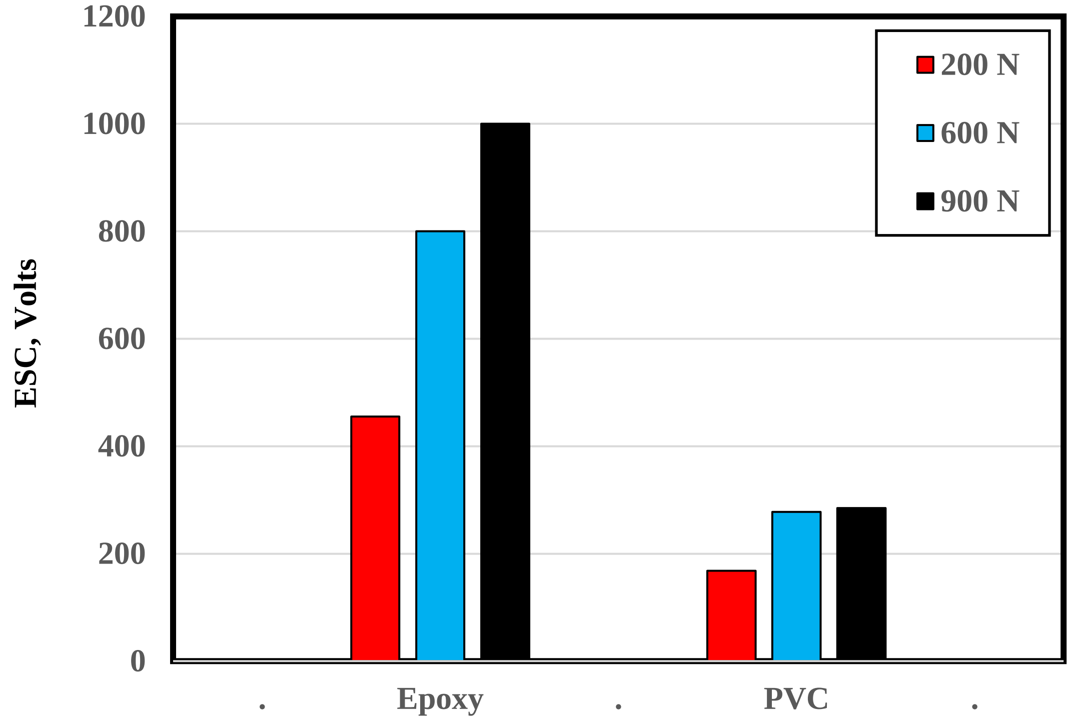

Fig. 10 ESC generated from water wet contact/separation of PE shoe cover and tested tiles.

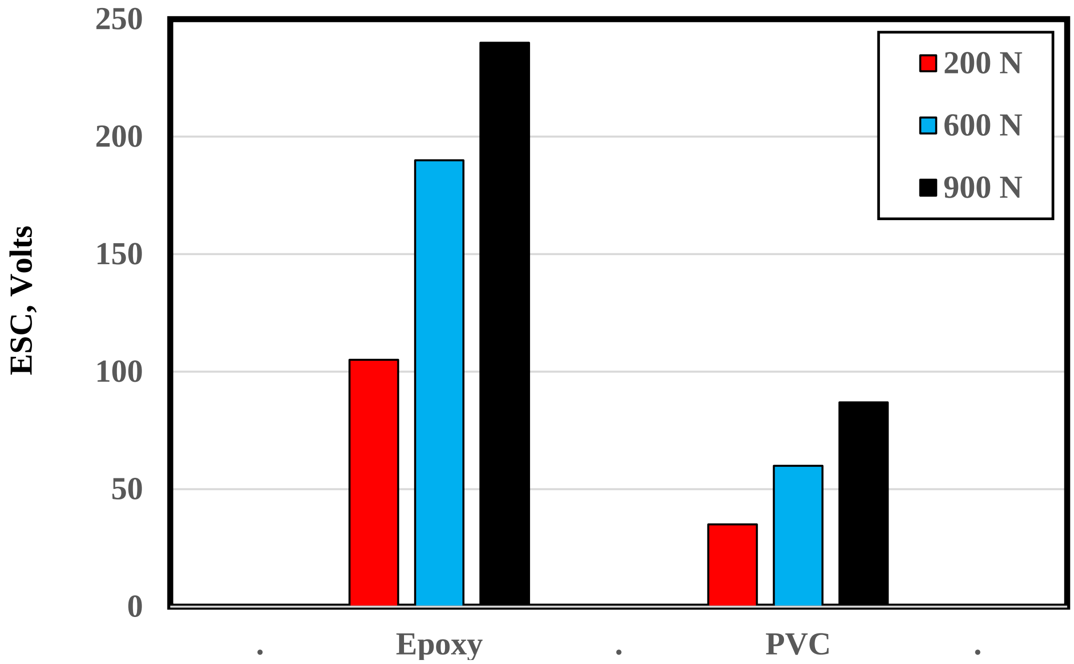

Fig. 11 ESC generated from water wet sliding of PE shoe cover and tested tiles.

The water wet contact/separation of PE shoe cover and tested tiles showed higher ESC than that observed for dry contact, Fig. 10, while sliding showed lower ESC values, Fig. 11. The behavior of the tested tiles and the PP shoe can be discussed on the bases of the triboelectric series. When two materials are in contact or slide on each other, the higher ranked one in the series gets positively charged while the other will be negatively charged. PP shoes used in hospitals gain negative ESC and epoxy gets positive ESC, Fig. 12. PVC floor gained negative ESC value due to its position in the triboelectric series, Table 1.

Fig.12 Illustration of the distribution of ESC on the sliding surfaces of PP shoe and the tested tile.

Table 1 Triboelectric series of engineering materials.

Positive charge
Human hands
Polymethyl methacrylate
Human hair
Polyamide
Cotton
Polyurethane elastomer
Hard rubber
Epoxide resin
Polyethylene
Polypropylene
Polyvinyl chloride
Polytetrafluoroethylene
Negative charge

According to the information of considering that the viruses have negative charge, it is necessary that shoes and shoe covers used in hospitals must be made of PP and PE respectively in order to repel viruses away from the wearers. To guarantee that the floor gains positive charge to attract the viruses, where the cleaning and disinfection of the floor are relatively easier. It is recommended to use epoxy floor than PVC.

CONCLUSIONS

1. Epoxy and PVC showed the highest friction coefficient values. In addition, they gained the lowest ESC values.
3. ESC gained by the surface of PVC tiles were lower than that gained by epoxy. At sliding, ESC displayed relatively higher values than contact/separation.
4. The contact/separation of water wet epoxy increased ESC values compared to dry contact.
5. Sliding of shoe cover on dry epoxy measured relatively higher values of ESC than PVC.
6. It is preferrable to apply epoxy floor to guarantee that the floor gains positive charge and attract the viruses, where the disinfection will be relatively easier.

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