EGTRIB Journal
JOURNAL OF
THE EGYPTIAN SOCIETY OF TRIBOLOGY
VOLUME 18, No. 1, January 2021, pp. 40 - 51 ISSN 2090 - 5882
(Received October 14. 2020, Accepted in final form November 23. 2020) www.egtribjournal.com

SELECTION OF FLOOR MATERIALS IN HOSPITALS TO RESIST COVID-19

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ABSTRACT
The present study discusses the electrostatic charge generated from the dry and wet sliding of shoe and shoe cover against floor in hospitals. Experiments have been carried out to measure the magnitude and sign of ESC generated on the surface of the polypropylene (PP) shoes and polyethylene (PE) shoe cover during contact and separation as well as sliding on two types of floor materials (epoxy and polyvinyl chloride). Taking into consideration that the novel coronavirus (COVID-19) has negative charge it is necessary that the surfaces of shoes and shoe covers of the health care workers should be made of materials that gain negative ESC to repel viruses away from the wearers. Because the disinfection and cleaning of the floor are regularly done it is preferable that the charge on the floor has positive charge to attract the viruses.

It is recommended that shoes and shoe covers used inside hospitals should be made of PP and PE respectively to repel viruses away from the wearers. Besides, it is proposed to apply epoxy floor instead of PVC tiles so that the floor acquires positive ESC to attract the viruses, where disinfection and cleaning are relatively easier. Shoes of rubber soles should be restricted inside the hospitals, while PP shoes are only permitted.

KEYWORDS
Floor, hospital, shoe, shoe cover, epoxy, polyvinyl chloride, health care, COVID-19.

INTRODUCTION
The protective equipment of medical care workers such as shoe, shoe cover, facemask, gloves, disposable cap and gowns are made of polymeric materials that generate ESC on their surfaces. ESC have double layer of different sign charge. Recently, [1], ESC generated on the gloves was studied to develop their protection of the wearer from viruses especially Covid-19. It was recommended to select the materials that gain strong

negative ESC to repel the viruses of negative ESC out of the surface of the glove. This behavior is offered by PE glove.

The recent researches showed that all viruses are coated with proteins that provide a partial negative charge to the virus, [2, 3]. It was revealed that the virus charge depends upon the charges of the genetic material and the protein. The high electric field influences the dipole of the protein of the virus, [4], causing destruction in terms of electroporation. The positive salt ions affect the viruses to be inactive and disintegrate. Besides, the structure of SARS-CoV N-NTD (lumen) indicates localized segregation of positive and negative charges, [5]. Recent studies, [6], suggested the presence of net negative charge in the core of the coronavirus.

Many trials were carried out to test polymeric composite fibers to work as protective textiles made of graphene oxide mixed with polymethyl methacrylate (PMMA) of antiviral ability to defeat negatively charged spike proteins of airborne viruses, [7]. ESC generated on the metallic foam to disinfect water was used, [8, 9]. It was proposed to use application of electric field for the capture of the virus particles due to the charge, [10, 11]. Cloths were developed to inactivate or repel coronaviruses such as COVID-19, [12, 13]. Silver and zinc are introduced on polyester textile. Silver and zinc generate an electric field that removes viruses on the surface.

Medical protective equipment are made of polymeric materials that they are easily triboelectrified. They gain ESC from rubbing each other. The electric field generated from ESC can attract or repel the charged particles, [14]. It is known that the material can acquire positive or negative ESC from contact and separation as well as sliding on another material. The materials are ranked due to their ESC by triboelectric series, [15 – 17]. Recently, it was found that the spread of COVID-19 can be retarded by the use of surgical masks because COVID-19 is a respiratory disease, [18 - 26]. Most viruses were reported to have negative charge, [27, 28], including COVID-19, [29]. Shoes and shoe covers are made of polymeric materials. It is necessary to know the sign and intensity of ESC they gain.

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 Shoe against epoxy floor. **Fig. 2 Shoe cover against PVC floor.**

The measurement of electrostatic charge (ESC) generated by the contact and separation as well as dry and water wet sliding of polypropylene shoe and polyethylene shoe cover against floor was carried out. Epoxy and polyvinyl chloride (PVC) tiles of 400 × 400 mm^2 as floor were tested. The experiments simulate the walking of people working in hospitals. ESC was measured by the electrostatic fields measuring device (Ultra Stable Surface DC Voltmeter). The tested floor tiles were adhered to a wooden base. The shoe and shoe cover were pressed to the tested tiles by foot, Figs. 1 and 2. Tests were carried out at room temperature under varying normal loads. Each measurement was replicated five times, and the mean value of the ESC was calculated.

RESULTS AND DISCUSSION

Triboelectrification of the dry floor due to its contact and separation with the rubber shoe sole is shown in Fig. 3. ESC increased with increasing the load due to the increase of the contact area and ESC transfer into the contact surfaces became easier. ESC generated on the epoxy floor had positive value, while PVC floor had negative one. The values of ESC increased up to +624 and -800 volts at 780 N load for epoxy and PVC floors respectively. At sliding, Fig. 4, the same trend was observed with relatively higher ESC values. Epoxy and PVC floors gained +3136 and -3828 volts at 820 N load respectively. The ESC generated on the floor is accompanied by another generated on the sole of the shoe with opposite sign.

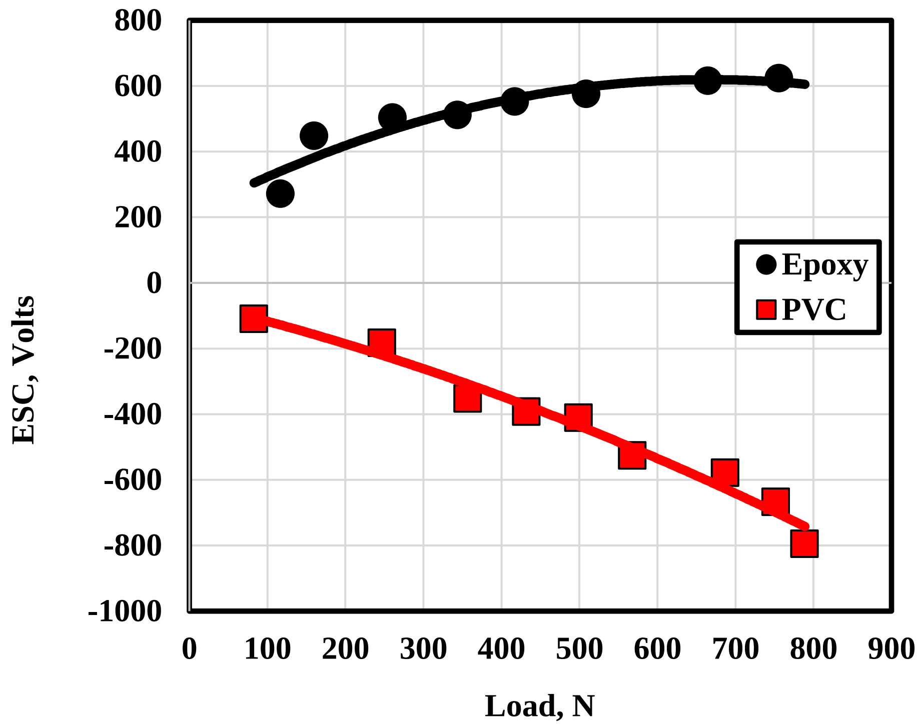


Fig. 3 ESC generated from dry contact and separation of shoe and floor.

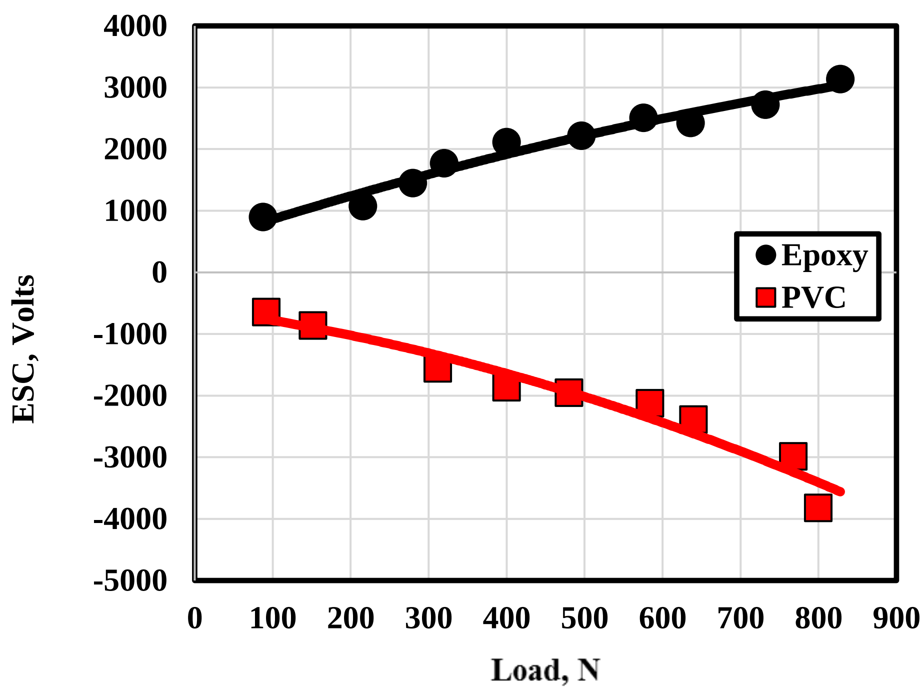


Fig. 4 ESC generated from dry sliding of shoe and floor.

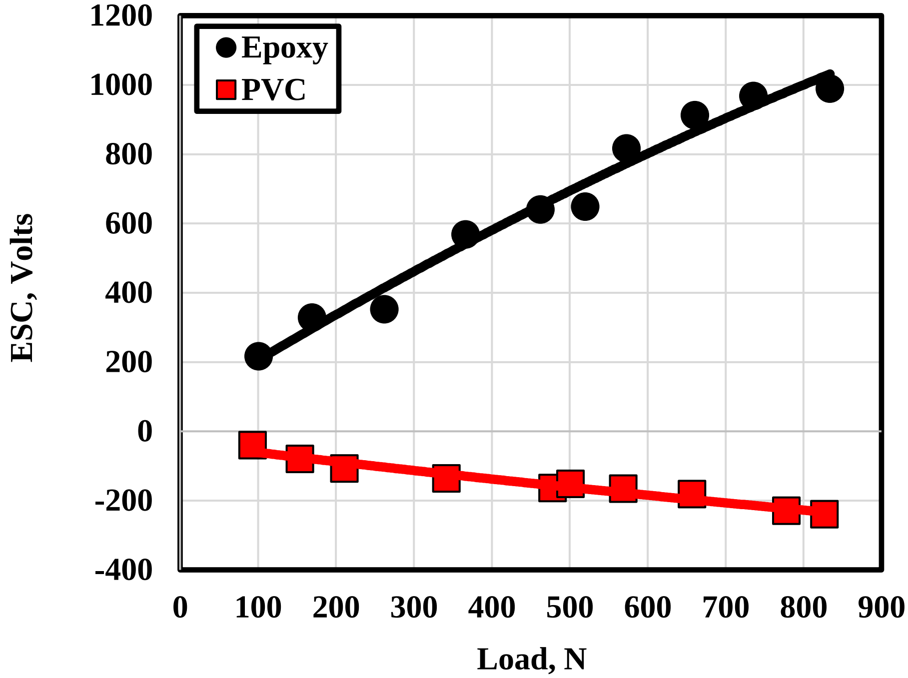


Fig. 5 ESC generated from water wet contact and separation of shoe and floor.

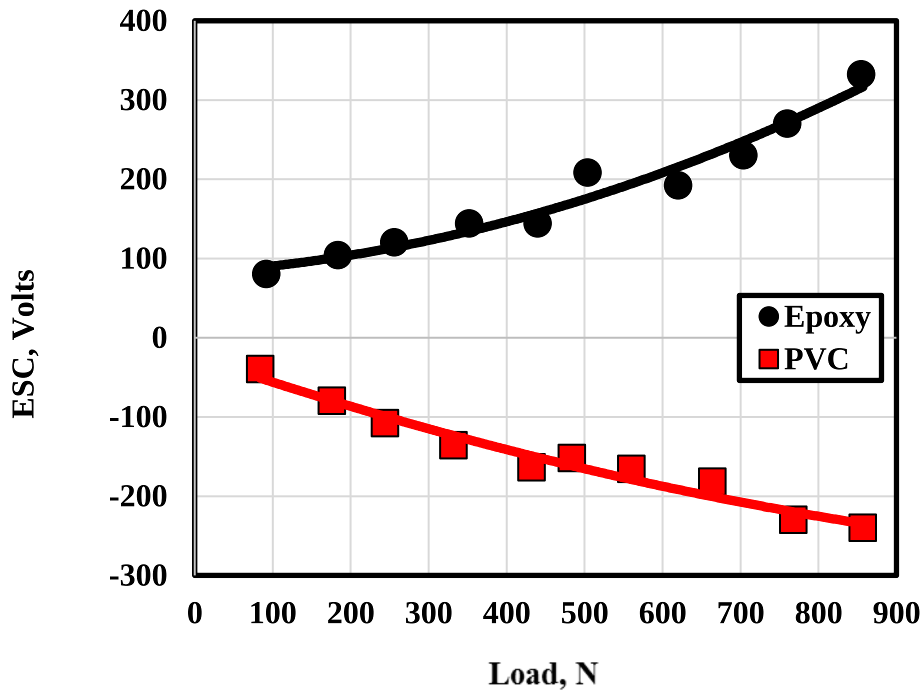


Fig. 6 ESC generated from water wet sliding of shoe and floor.

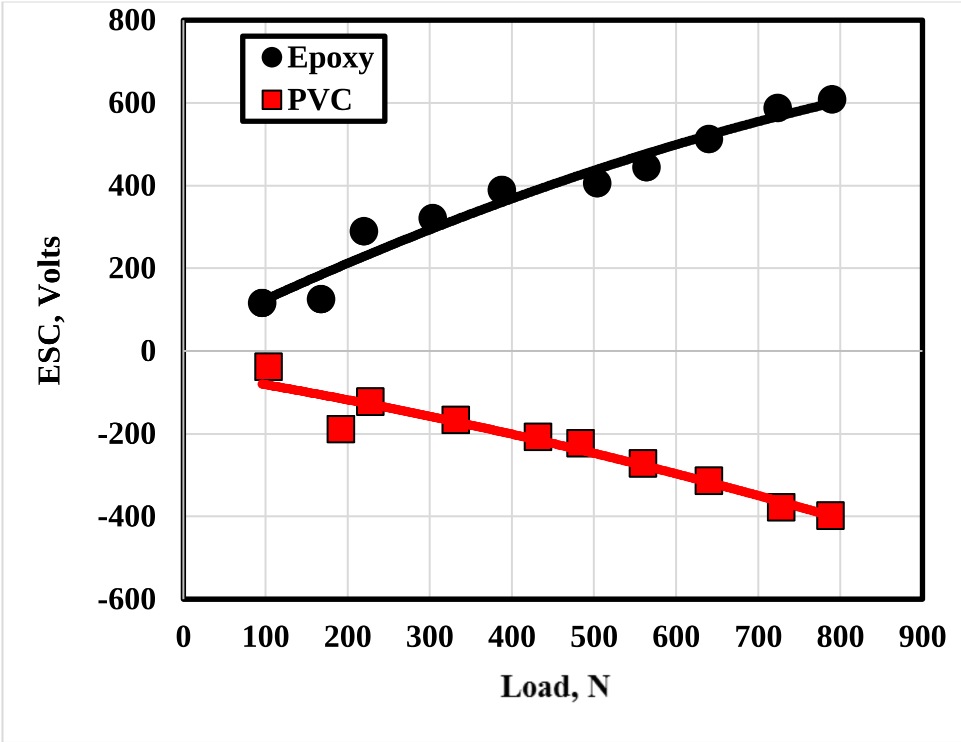


Fig. 7 ESC generated from dry contact and separation of shoe cover and floor.

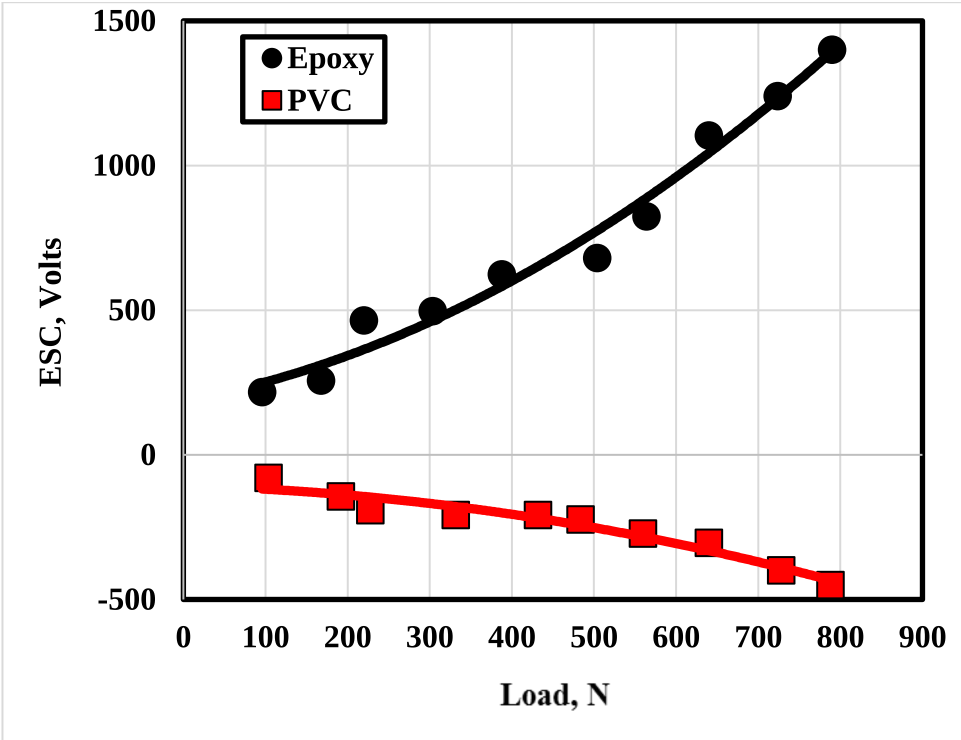


Fig. 8 ESC generated from dry sliding of shoe cover and floor.

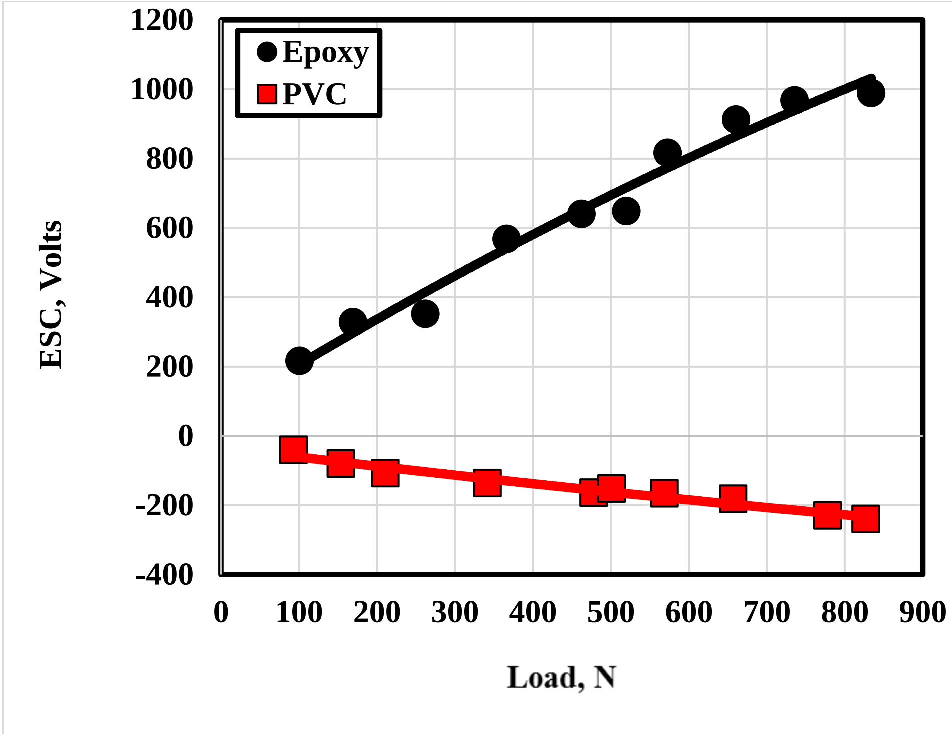


Fig. 9 ESC generated from water wet contact and separation of shoe cover and floor.

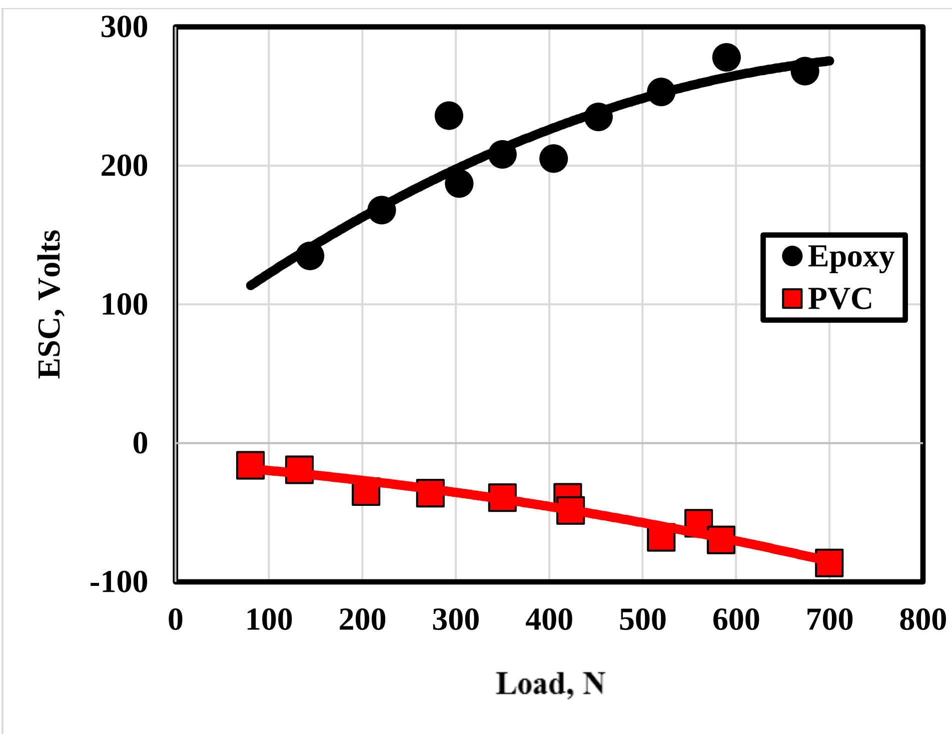


Fig. 10 ESC generated from water wet sliding of shoe cover and floor.

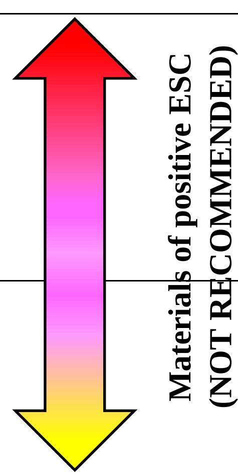
The water wet surfaces showed slight increase in ESC values for epoxy at contact and separation, Fig. 5, where the highest recorded value was +989 volts while PVC gained lower value that did not exceed -240 volts. At sliding, Fig. 6, epoxy floor gained relatively lower ESC than that observed at contact and separation (+332 volts). It seems that the squeeze action was effective in contact and separation the sliding, where the formation of water film in sliding was responsible in distributing and exchanging ESC between the two contact surfaces because of the ability of water to conduct the double layers ESC of different signs from the contact surfaces of both the floor and sole.

Fig. 11 Generation of ESC on the sliding surfaces of rubber shoe and epoxy floor.

Fig. 12 Generation of ESC on the sliding surfaces of PP shoe and epoxy floor.

Table 1 Triboelectric series of engineering materials.

Positive charge
Air
Silicone elastomer
Human hands
Window glass
Rabbit fur
Polymethyl methacrylate



Human hair	
Polyamide	
Aluminum	
Paper	
Cellulose acetate	
Cotton	
Polyurethane elastomer	
Wood	
Styrene-butadiene	
Polystyrene	
Hard rubber	
Polyethylene glycol terephthalate	
Epoxide resin	
Polyester	
Natural rubber	
Polyacrylonitrile	
Polystyrene	
Polyethylene	
Polypropylene	
Polyvinyl chloride	
Polytetrafluoroethylene	
Negative charge	

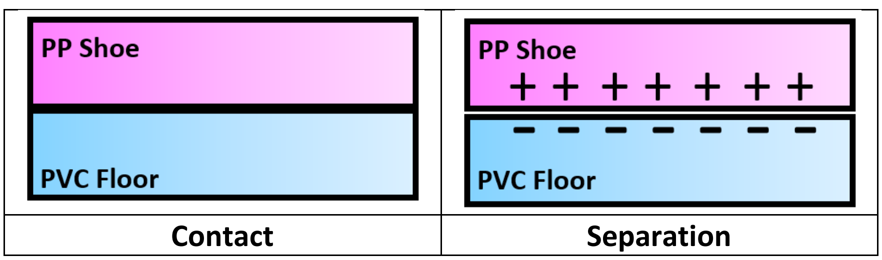


Fig. 13 Generation of ESC on the contact and separation of the surfaces of PP shoe and PVC floor.

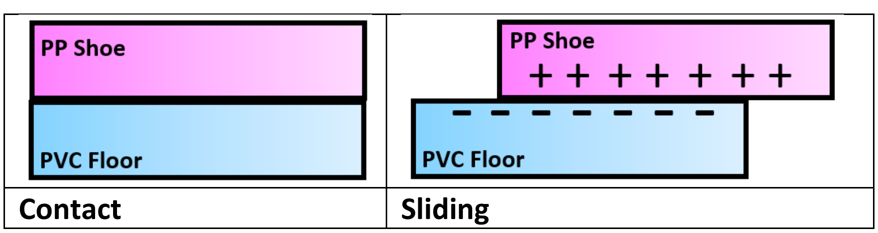


Fig. 14 Generation of ESC on the sliding of the surfaces of PP shoe and PVC floor.

The following figures 7 – 10 show the ESC generated on the tested floors when PE cover was in contact and separation as well as sliding on them. At dry contact and separation, Fig. 7, ESC generated on epoxy and PVC floors were +608 and -398 at 790 N load respectively. At sliding, Fig. 8, it was observed that ESC was much higher than that

measured for contact and and separation. When the tested floors were water wet, Fig. 9, ESC displayed lower values that reached +989 and -240 volts for epoxy and PVC respectively at contact and separation. At sliding of shoe cover against water wet epoxy floor, Fig. 10, ESC recorded lower values that did not exceed 268 volts. It seems that, the low values of charge were from the water film that conducted ESC from the two contact surfaces.

Based on the triboelectric series, when two materials contact or slide on each other, the higher one in the series will get positively charged while the other will be negatively charged. Rubber shoes gain positive ESC and epoxy has negative ESC, Fig. 11. The material of shoe sole used in hospitals is polypropylene that is ranked as negative charged material, Fig, 12, while epoxy is above polypropylene so it is positive charged. PVC floor gained relatively higher negative ESC value due to its position in the triboelectric series, Table 1. That can explain the negative ESC gained by PVC floor due to the action of PP shoe as well as PE cover, Figs. 13 and 14, where illustration of the ESC distribution after contact and separation as well as sliding is shown.

Based on the specific information of considering that the novel coronavirus (COVID-19) has negative charge, shoes and shoe covers of the health care workers in hospitals should be made of materials that gain negative ESC (polypropylene and polyethylene) to repel viruses away from the wearers. It is preferable that the floor acquire positive charge to attract the viruses because the disinfection and cleaning of the floor are relatively easier. It is recommended to use epoxy floor than PVC.

CONCLUSIONS

1. Contact and separation as well as sliding of PP shoes on the tested floor generated positive ESC on the epoxy floor, while PVC floor gained negative one. At sliding, ESC recorded relatively higher values than contact and sliding.
2. At water wet floors, contact and separation showed higher values than that observed in sliding.
3. The same trend was detected for the PE cover with lower ESC values.
4. It is recommended that shoes and shoe covers of the health care workers in hospitals should be made of polypropylene and polyethylene respectively to repel viruses away from the wearers.
5. It is proposed that the floor should acquire positive ESC to attract the viruses, where disinfection and cleaning of the floor are relatively easier. Epoxy floor is preferable to applied instead of PVC tiles. Shoes of rubber soles are prevented inside the hospitals.

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