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ELECTROSTATIC CHARGES GENERATED ON THE MEDICAL CLOTHES

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ABSTRACT

The present work discusses the electrostatic charges (ESC) generated on the surface of the protective equipment of people working in the medical care such as uniform, gloves, disposable gowns and eye drape to control their effectiveness to protect the wearer from viruses such as Covid-19.

The experimental observations showed that ESC generated from contact and separation of the doctor uniform and doctor gown slightly increased with increasing the applied load. Sliding generated relatively higher ESC than that observed in contact and separation. It is known that negative ESC generated on the gown is preferable to repel the viruses of negative charge such as Covid-19. The relatively high negative ESC gained by the gown can protect the doctor from infection. After contact and separation of latex gloves and gown, latex gloves gained relatively higher positive ESC that represents higher risk of attracting the negative charged viruses into the gloves and increases the possibility to infect other persons. Based on that, latex gloves should be replaced by PE (polyethylene) gloves to gain relatively lower values of ESC.

It is known the gowns gained negative ESC are able to provide protection for the wearer against infection. In addition to that, contact and separation as well as sliding of doctor gown and patient gown generated negative ESC on the doctor gown. Polypropylene (PP) gown ensures the repulsion of the negative charged viruses including Covid-19 away. Finally, ESC generated on the medical cloth surfaces generate electric field that could ionize the air around the charged surfaces. Surfaces of negative ESC generate electric field that can ionize the air by negative ESC able to repel the viruses away of the surface.

KEYWORDS

Health care, protective equipment, COVID-19, uniform, gloves, disposable gowns, eye drape.

INTRODUCTION

The protective equipment of medical care workers should gain strong negative ESC to repel the viruses of negative ESC such as Covid-19 out of their surface. Based on that, actively negative charged polymers should be selected for masks, [1]. On the other hand, polyamide cotton, and PMMA should be limited. It is proposed that, the material of goggles should be made from PE, PP and PVC, because they gain strong negative ESC that able to repel the viruses out of the wearer, [2]. In addition to that, negative ESC generated on the surface of goggle can ionize the air in the front of the goggle to be negatively charged and provide region of negative ESC. Inside hospitals, it was proposed, [3], that shoes and shoe covers should be made of PP and PE respectively to repel viruses away from the wearers. In addition to that, it is recommended to use epoxy floor instead of PVC tiles to enable the floor to gain positive ESC to attract the viruses, where cleaning and disinfection are relatively easier. Rubber outer soles of shoes should be limited inside the hospitals, while PP shoes are favorable. 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, [4]. This behavior is offered by PE glove.

It was indicated that all viruses are coated with proteins, where they contain DNA or RNA, [5, 6], that provides negative charge to the virus. The high electric field influences the induced dipole of the virus protein, [7], causing damage. Some positive salt ions can diffuse into the protein of the viruses and limit its activity and integration. Besides, the structure of SARS-CoV N-NTD indicates localized segregation of positive and negative charges, [8]. It was suggested that, [9], residual of net negative charge exists in the core of the coronavirus.

Polymeric composites made of graphene oxide (GO) layer and polymethyl methacrylate (PMMA) of antiviral activity proved to defeat negatively charged spike proteins of airborne viruses, [10]. ESC and electric field over the metallic foam could disinfect water, [11, 12], where coating of carbon nano-tubes CNT over the metallic filter were applied to disable the viruses. Electric field was used to capture the virus because they are charged, [13]. The X-ray proved to be able for nanoparticle capture, [14]. In addition to that, it can inactivate the trapped biological germs.

Experiments were performed to develop textiles that can inactivate and repel COVID-19 viruses, [15, 16]. The electroceutical materials can generate electric fields on the surface of the textiles to limit the activity of bacteria or viruses. Silver and zinc were printed on polyester textile generate a weak electric field that zaps viruses when the textile gets wet with saliva and coughed up droplets.

Medical protective equipment are made of polymeric woven and nonwoven textiles. They are actively triboelectrified, where they gain ESC from rubbing each other and generate the electric field that can attract or repel the electrically charged particles, [17]. In triboelectrification, the material gains positive or negative charge from the contact and separation as well as sliding on another material. The triboelectric series classifies materials due to their ESC, [18 – 20]. It was proposed to use surgical masks to retard the

spread of COVID 19, [21 - 26]. ESC generated on the surfaces of the surgical masks made of Polymeric materials can capture or repel the viruses, [27 - 30]. It was indicated that the majority of viruses has negative ESC, [31, 32], including COVID-19, [33]. Because medical protective equipment are made of polymeric materials, it is essential to determine the sign and intensity of ESC they gain.

The present work determines the ESC generated on the medical protective equipment of people working in health care and discusses the possibility to recommend the proper materials suitable for that purpose.

EXPERIMENTAL

The present work investigates the ESC generated by the contact and separation as well as the sliding of the tested materials such as doctor uniform, gown, latex glove and eye drape. The material of the uniform is cotton while the material of gown is polypropylene (PP). Latex is the material of the gloves and polyester is material of eye drape.

Fig. 1 Electrostatic field measuring device.

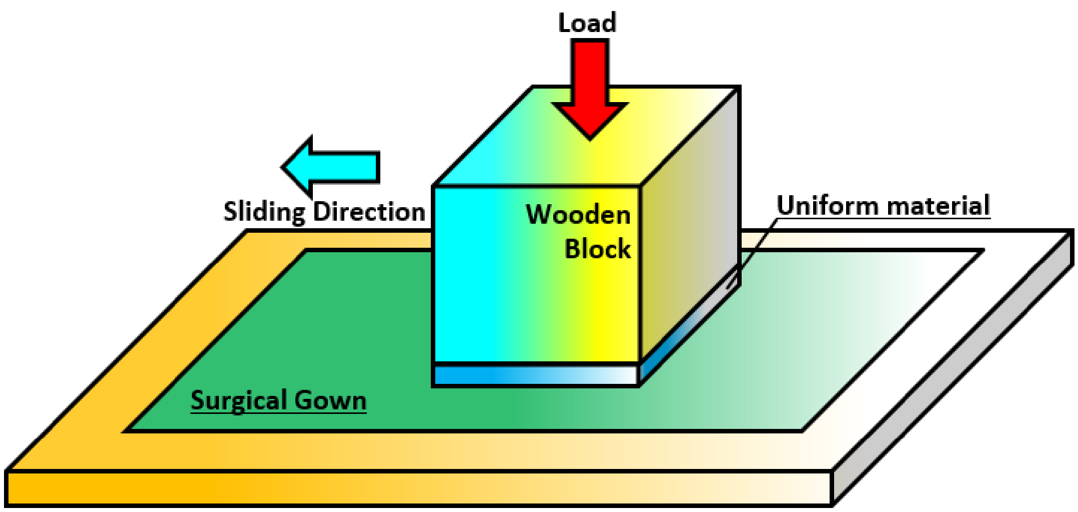

Fig. 2 Arrangement of test procedure.

Ultra Stable Surface DC Voltmeter was used to measure ESC through the generated electrostatic field. The tested materials in form of strips were adhered to the wooden table of 400 × 400 mm^2, were wooden block of 50 × 50 mm^2 was adhered by the counterface, Fig. 2. Tests were carried out under normal loads ranged from 10 to 80 N. The wooden block was normally loaded by 10 to 80 N and slid manually for 200 mm distance. The measurement of ESC was carried after sliding as well as contact and separation.

RESULTS AND DISCUSSION

The sliding as well as contact and separation of on each other can generate ESC, where each material acquires charge of opposite polarity. Figure 3 illustrates the classification of some of the engineering materials in the triboelectric series. The materials are ranked according to their relative ESC polarity.

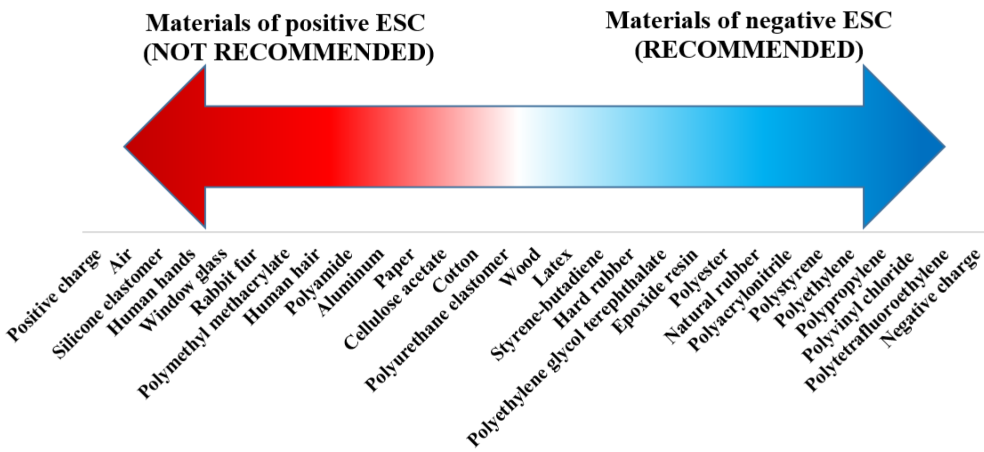

Fig. 3 Triboelectric series of engineering materials.

ESC generated from contact and separation of the doctor uniform and doctor gown are shown in Figs. 4. ESC slightly increased with increasing the applied load. The values of ESC generated on the uniform and gown were +580 and -620 volts respectively. The negative ESC on the gown is preferable to repel the viruses and bacteria of negative charge. Sliding of doctor uniform and gown, Fig. 5, generated relatively higher ESC than that observed in contact and separation. The highest ESC values recorded for uniform and gown approached +750 and -900 volts at 85 N load respectively. The relatively high negative ESC gained by the gown can protect the doctor from infection.

Contact and separation of latex gloves and gown displayed +150 and -175 volts of ESC values respectively, Fig. 6, while sliding of glove on gown showed relatively higher values of ESC, Fig. 7. Gloves gained +2100 volts that represents high risk of attracting the negative charged viruses into the gloves and raises the possibility to infect other people. The illustration of the distribution of ESC on the surfaces of gloves and doctor gown is shown in Fig. 8. On the other side, gown gained -2600 volts that provide quite good protection for the wearer against infection. Based on that observation, it is recommended to use PE glove material to gain lower values of ESC.

Contact and separation of doctor gown and patient gown generated relatively low values of ESC, Fig. 9. Fortunately, negative ESC was generated on the doctor gown considering the safety of the medical crews. The same trend was observed for sliding, Fig. 10. Because the doctor gown is made of PP that ranked in the triboelectric series as active negative charged material, the repulsion of the negative charged viruses including Covid-19 away of the doctor gown is confirmed.

Figures 11, 12 show the ESC generated from contact and separation as well sliding of doctor gown and eye drape. Contact and separation of doctor gown and eye drape is displayed in Fig. 10. Eye drape gained +70 volts at 85 N load, while the value of ESC increased up to +110 volts at sliding, Fig. 11. ESC generated on doctor gown gained negative sign. The negative ESC on the surface of doctor gown can exert a repulsive force against the viruses in the air.

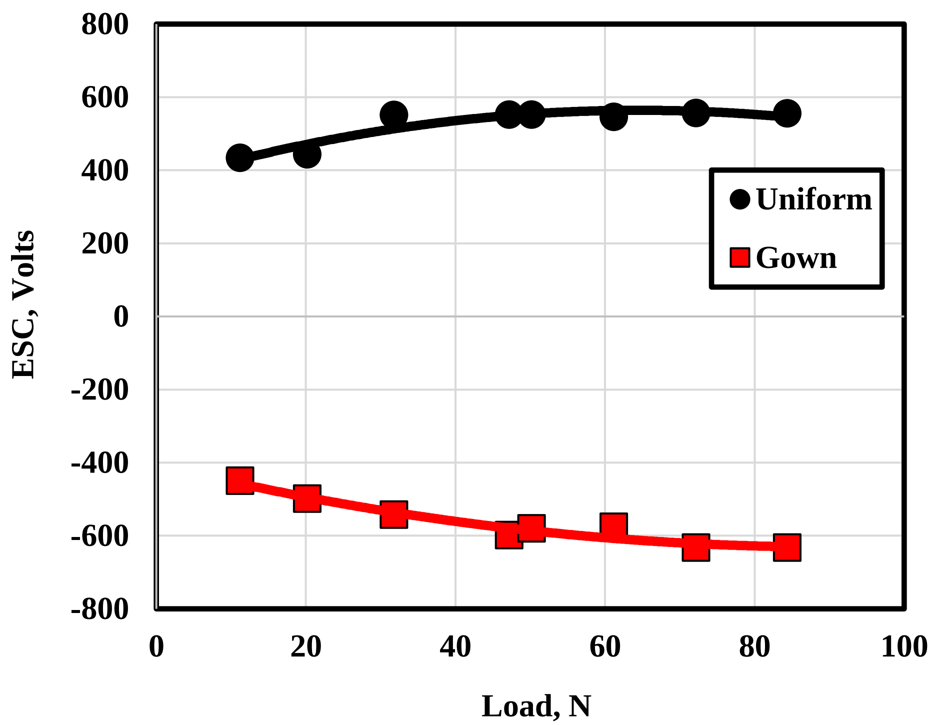

Fig. 4 ESC generated from contact and separation of doctor uniform and gown.

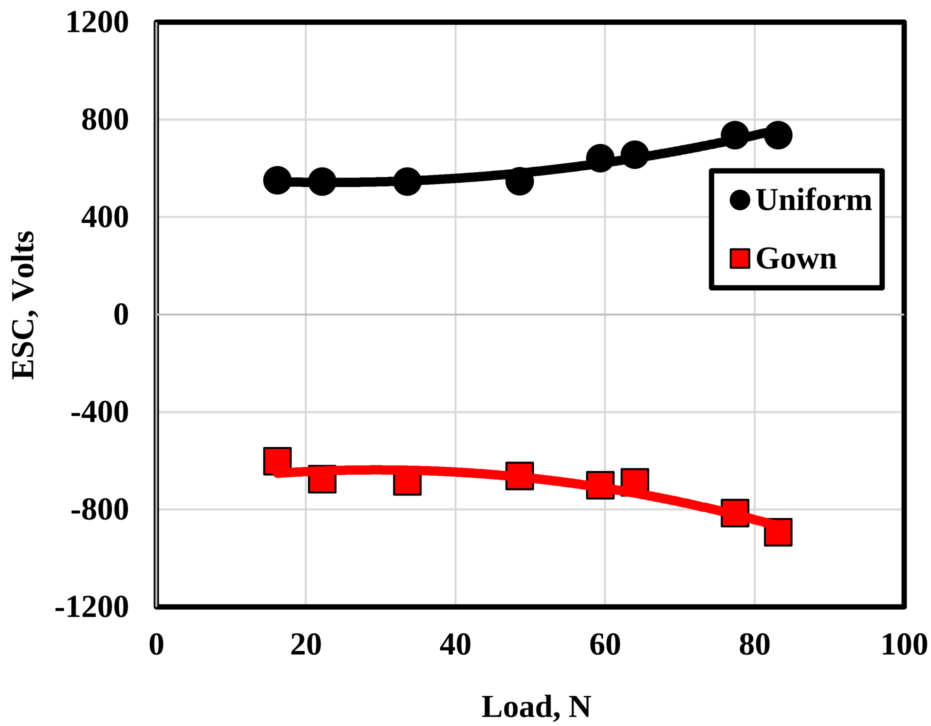

Fig. 5 ESC generated from contact and sliding of doctor uniform and gown.

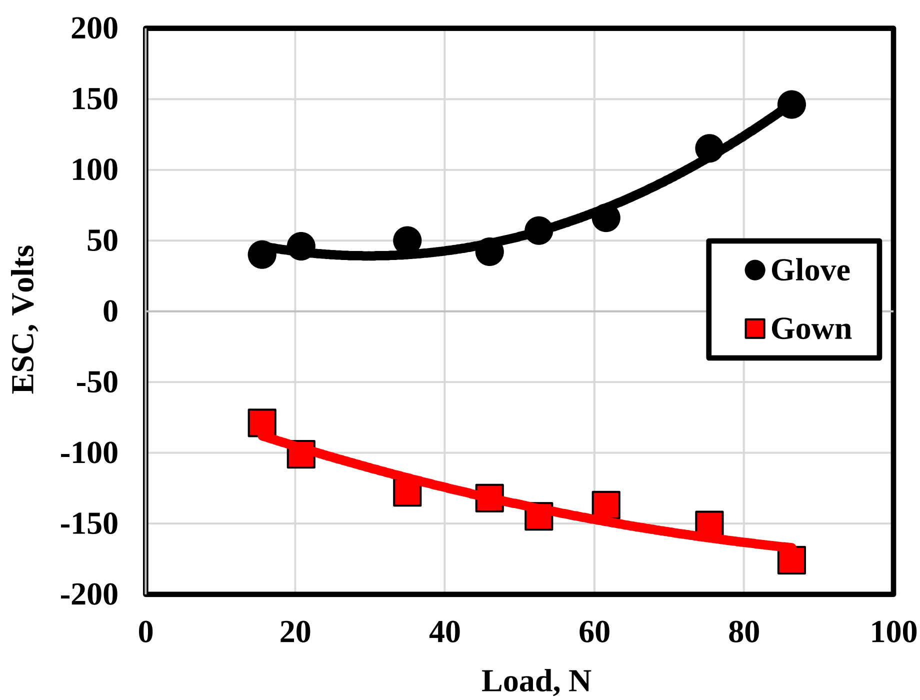

Fig. 6 ESC generated from contact and separation of doctor glove and gown.

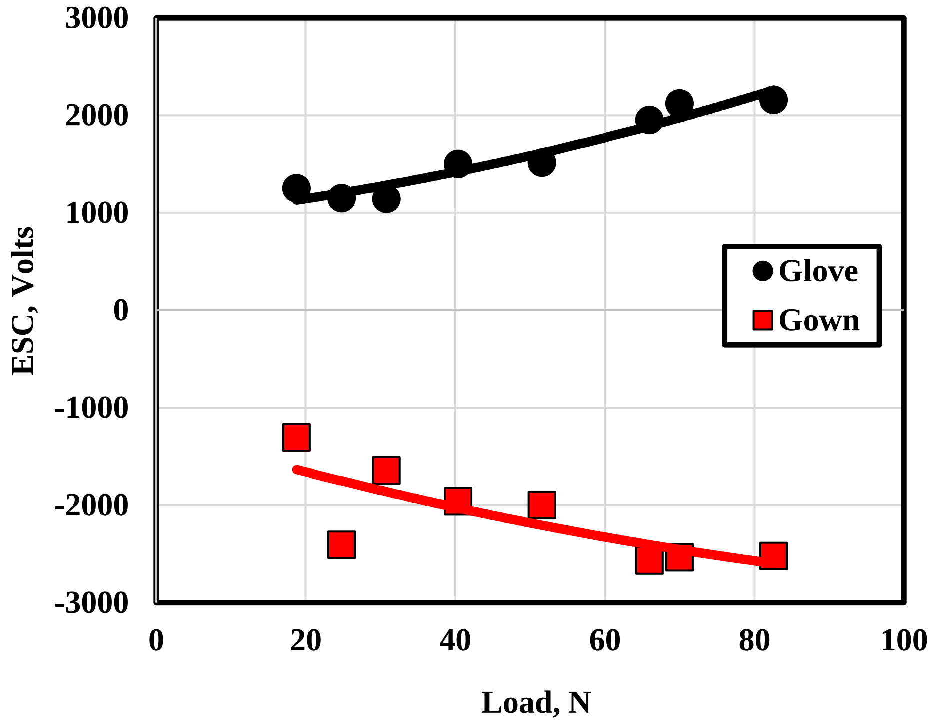

Fig. 7 ESC generated from sliding of doctor glove and gown.

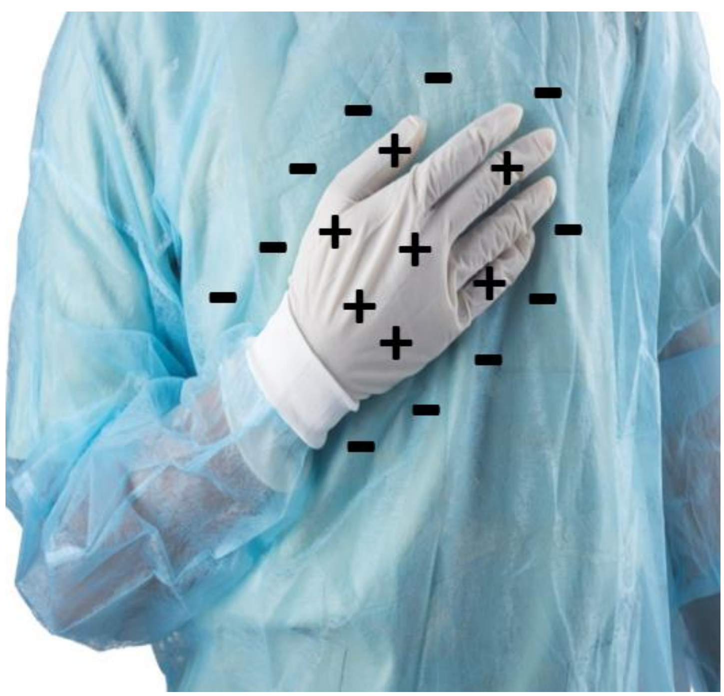
Fig. 8 illustration of the distribution of ESC on the surfaces of gloves and doctor gown.

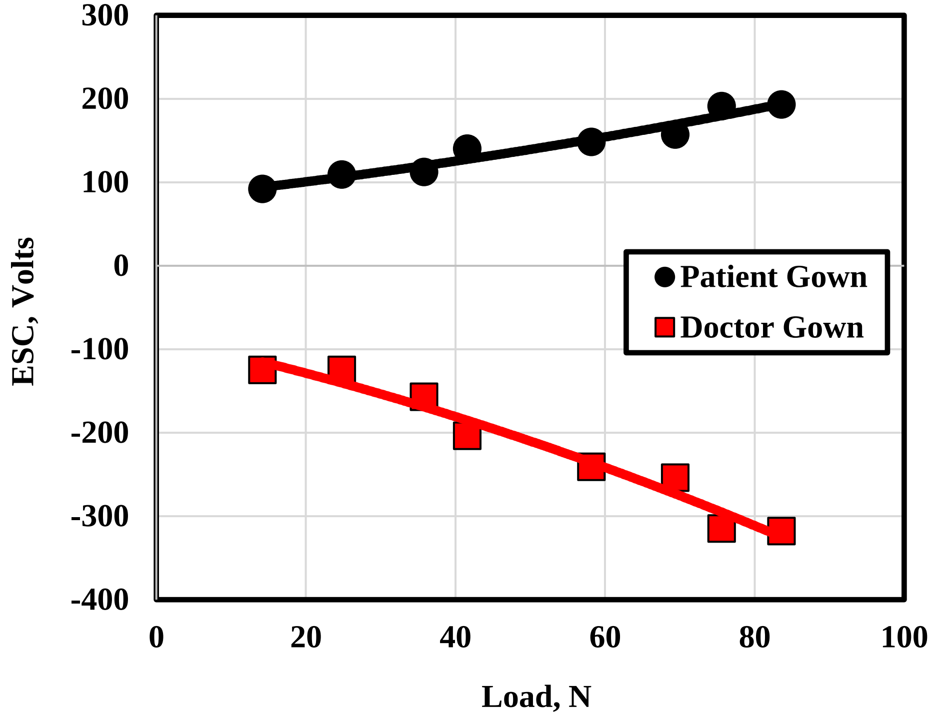

Fig. 9 ESC generated from contact and separation of doctor gown and patient gown.

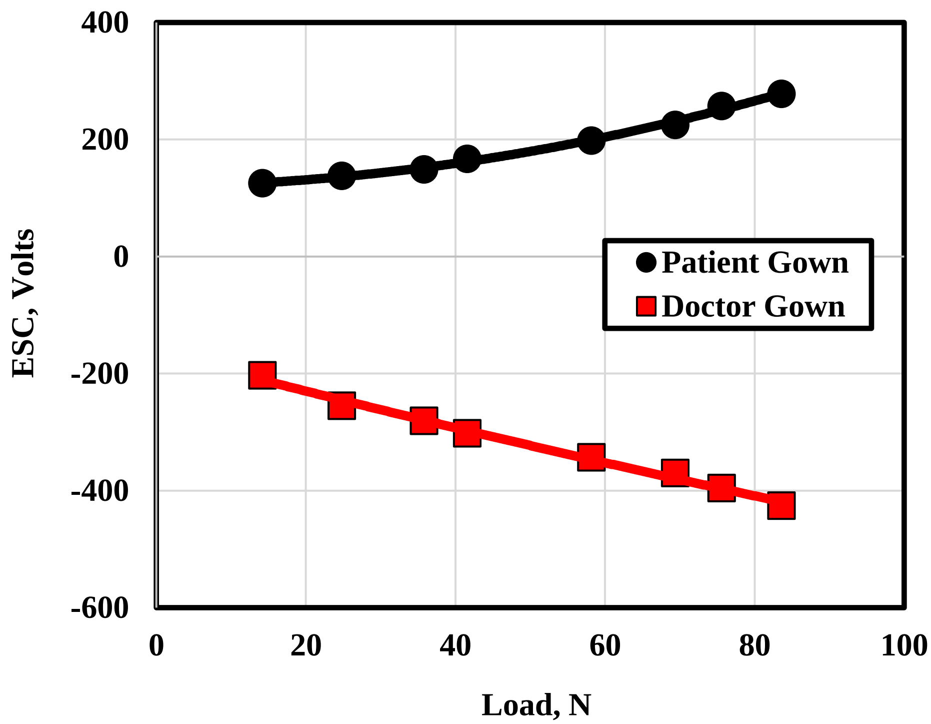

Fig. 10 ESC generated from sliding of doctor gown and patient gown.

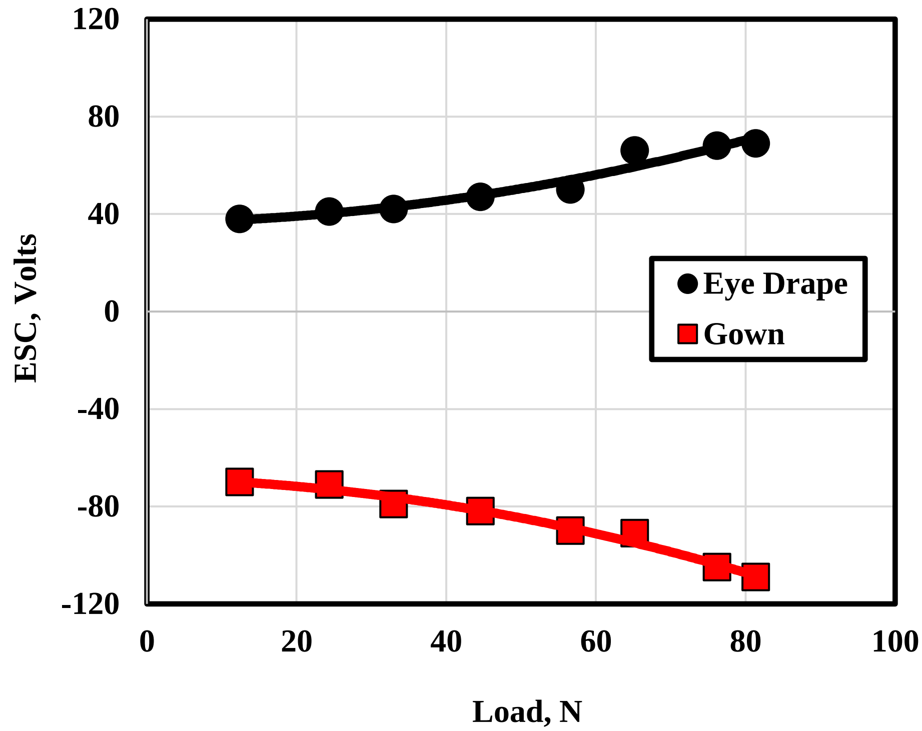

Fig. 11 ESC generated from contact and separation of doctor gown and eye drape.

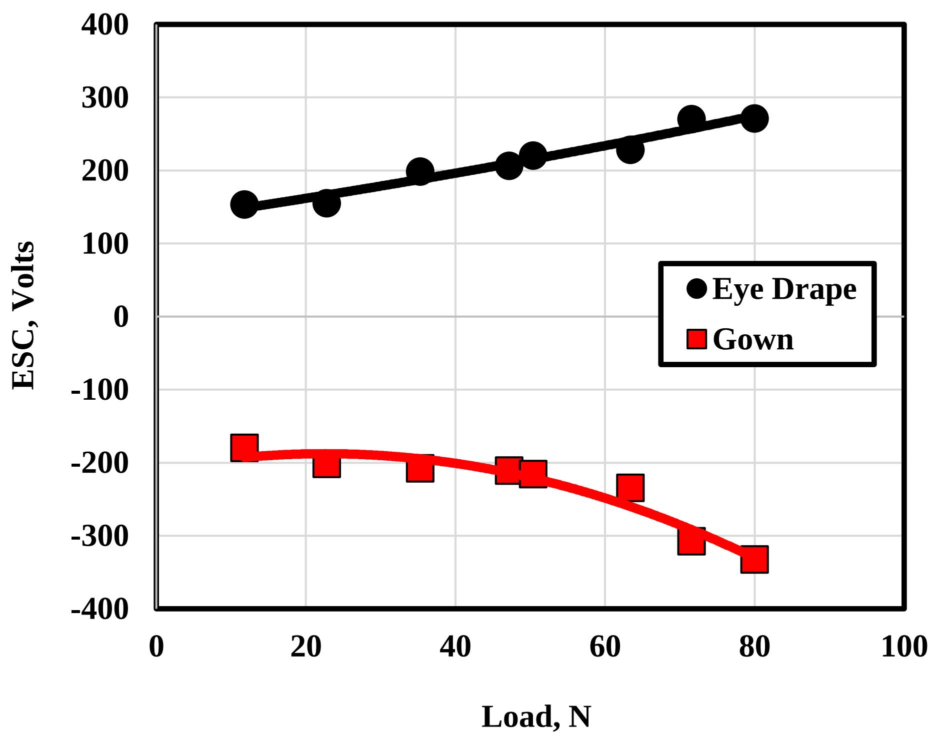

Fig. 12 ESC generated from sliding of doctor gown and eye drape.

Polymeric textiles have low mobility of electrons and localize ESC, [34]. At contact and separation as well as sliding, the trapped charges can be released, [35], causing the dielectric breakdown. The fibers fineness influences the movement of the free electrons. The medical protective clothes are made of woven and nonwoven polymeric textiles that are triboelectrified materials, where double layer of ESC on the two sliding surfaces is generated. When the two materials are rubbed or pressed together, the surface of the first one becomes positive charged and the second becomes negative charged. The magnitude of ESC depends on the load and rubbing velocity. ESC on the two surfaces generate electric field that could ionize the air around the two charged surfaces. Surfaces of negative ESC generate electric field that can ionize the air by negative ESC able to repel the viruses away of the surface.

CONCLUSIONS

1. ESC from contact and separation of the doctor uniform and doctor gown slightly increased with increasing the applied load. Sliding generated relatively higher ESC than that observed in contact and separation.

2. The negative ESC generated on the gown is preferable to repel the viruses and bacteria of negative charge and can protect the doctor from infection.

3. After contact and separation of latex gloves and gown, latex gloves gained relatively high positive ESC that represents high risk of attracting the negative charged viruses into the gloves and increases the possibility to infect other persons. Gown gained negative ESC able to provide protection for the wearer against infection.

4. Latex gloves should be replaced by PE glove material to gain relatively lower values of ESC.

5. Contact and separation of doctor gown and patient gown generated negative ESC on the doctor gown. PP gown ensures the repulsion of the negative charged viruses including Covid 19 away.

6. Generation of ESC on the two surfaces generates electric field that could ionize the air around the charged surfaces, where the negative ESC can be able to repel the viruses away of the surface.

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