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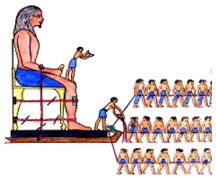

PROPER SELECTION MATERIALS OF FACE SHIELDS, EYEGLASSES AND GOGGLES

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ABSTRACT
Experiments have been carried out to measure the magnitude and sign of ESC generated on the surface of the protective equipment such as face shields, eyeglasses, and goggles to improve their effectiveness to protect the wearer from viruses. It was found that the face shield made of polypropylene (PP) generated negative ESC. Because the novel coronavirus (COVID-19) has negative charge, it is necessary that the surfaces of lenses of goggles and eyeglasses as well as face shields for health care workers should be made of materials that gain negative ESC to repel viruses away from the wearers and protect their eyes from infection.

KEYWORDS
Protective, equipment, health care, COVID-19, face shield, goggles, eyeglass.

INTRODUCTION
Polymeric materials are applied extensively in the protective equipment of people who are working in health care. Medical face masks, goggles, face shields, gloves, and gowns are made of polymers that they are electrified easily. Polymeric materials carry electric charges when they rub against other materials, where the electric field can attract or repel the electrically charged particles, [1]. Triboelectrification is the process, where different surfaces gain different types and magnitudes of charge when they come into contact, [2 – 5]. The material has a tendency of gaining a positive or a negative charge when it contacts or rubs another material. The triboelectric series was introduced to rank materials according to their triboelectrification, where the higher the position of the material in the triboelectric series, the more likely it is to obtain a positive charge when it comes in contact with another material in the lower section of the series, [6 – 8].

Surgical masks are used by surgeons to protect themselves from large droplets, [9]. Because COVID-19 is a respiratory disease, surgical masks are identified as a possible option to prevent the spread of COVID-19, [10 - 14]. Based on this fact, face masks were proposed to withstand the severe conditions where virus concentration increases. The

proposal discussed the possibility of making use of the electrostatic charge (ESC) generated on the surfaces of the surgical masks to capture or repel the viruses.

The spread of COVID-19 has been a very pressing issue in the global domain, and one of the most important things to focus on during this time is the safety of all healthcare workers, for that, face shields were identified as a viable option to help protect them, [15, 16]. This is especially important because the spread of COVID-19 can occur via airborne routes according to initial investigations, [17 - 18].

Most viruses have a negative charge, ESC, [19 - 21]. This includes COVID-19, [22]. Face shields are usually made of polycarbonate (PC), acetate, or polyethylene terephthalate glycol (PETG). PC is the most commonly used. Besides, the above-mentioned materials are located in the positive section of the triboelectric series, [5, 6 and 23]. It means that they obtain a tendency to gain a positive charge when they contact other materials. It is also important to note that air is also on the upper side of the triboelectric series.

This study discusses the role of triboelectrification in improving the effectiveness of face shields and eyeglasses to protect the wearer from viruses. The proposal discusses the possibility of making use of the electrostatic charge (ESC) generated on the surfaces of the polymeric materials of protective equipment and recommending the proper materials.

EXPERIMENTAL

The protective equipment of people who are working in health care includes gloves, medical face masks, goggles, face shields, and gowns. High levels of precaution are required to protect them. These precautions include selecting proper materials for the protective equipment for infection prevention and control of respiratory infections. Experiments were carried out to measure the ESC generated from rubbing eyeglasses as well as face shields by different materials. Thirteen goggles and one eyeglass of different materials as well as face shield made of polypropylene (PP) were rubbed by cotton, paper, textile, and rabbit fur to recognize the sign of the ESC generated on their surfaces. The tested surfaces were washed by detergent and dried by air before the test. The electrostatic field (voltage) measuring device (ULTRA STABLE SURFACE DC VOLTMETER) was used to measure the ESC, Figs. 1, 2. It measures down to 1/10 volt on a surface, and up to 20 000 volts (20 kV). Readings are normally done with the sensor 25 mm apart from the surface being tested.

Fig. 1 Electrostatic field measuring device.

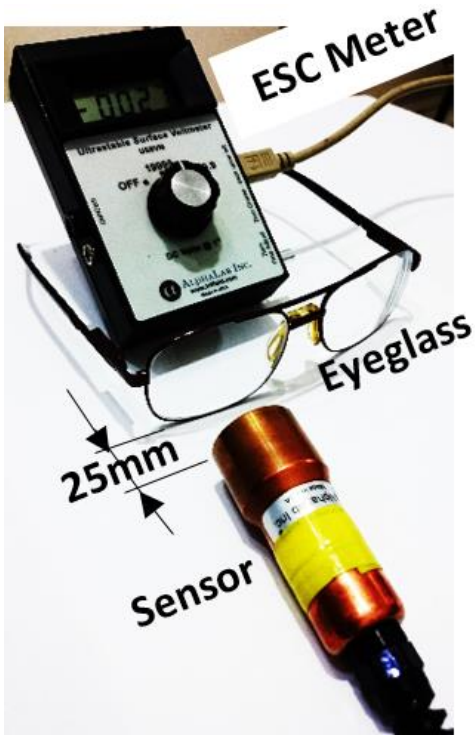


Fig. 2 Measuring Procedure.

RESULTS AND DISCUSSION

The results of the experiments carried out to measure ESC generated on the outer surface of the face shield are shown in Fig. 3. The face shield was washed by detergent, dried and rubbed by cotton. Then ESC was measured for 40 minutes. ESC recorded for the face shield was ranging between -2000 and -2700 volts. Generally, ESC slightly decreased with increasing the time. When the wearer used a face mask and the face shield, ESC recorded higher values reached to -4900 volts then decreased to -2950 volts after 40 minutes. It seems that the material of the face shield (PP) was responsible for the negative ESC. The face mask was made of PP that added more negative ESC to the face shield.

In addition to that, it is necessary for health care workers to use goggles or eyeglasses to protect their eyes from infection. The lenses should be made of materials that gain negative ESC. It was shown that ESC generated on the surface of the lens of eyeglasses versus time recorded relatively higher values of positive ESC. The right lens showed higher values than the left one that decreased from 5000 to 176 volts in 45 minutes. This type of eyeglass is not recommended to be used.

ESC generated on the surface of the lenses of the tested thirteen goggles after rubbing by different materials is illustrated in Figs. 5 - 9. Before measurement, the lenses were gently rubbed by cotton, paper, textile, and rabbit fur. Besides, water vapor was used to rinse the lens. It was noticed that lenses rubbed by cotton, paper, rabbit fur recorded the highest ESC values followed by textile and water vapor. The highest value of ESC reached -1466 volts noted for paper rubbing, Fig. 5. It was found that the deviation in ESC generated from the two lenses was significant.

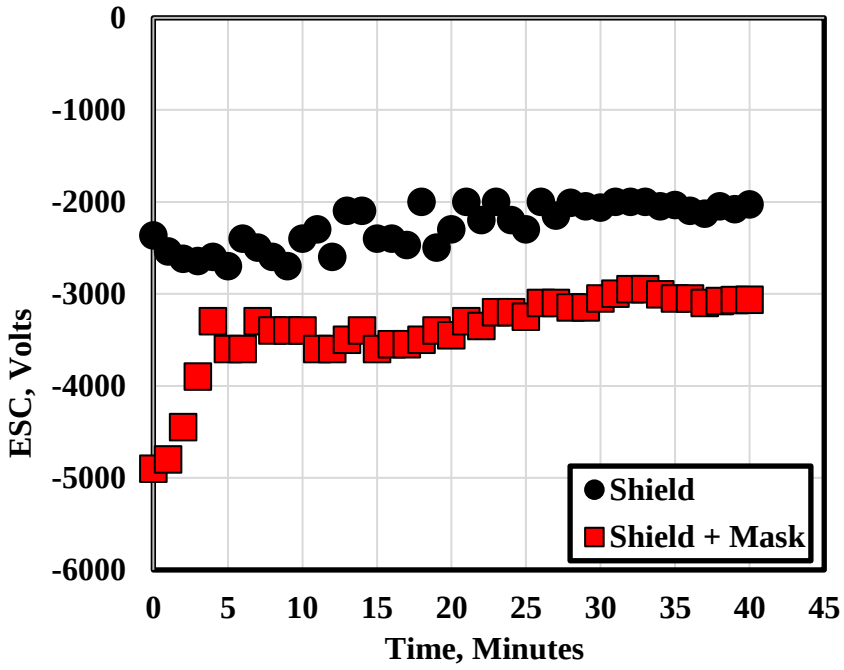


Fig. 3 ESC generated on the surface of face shield versus time.

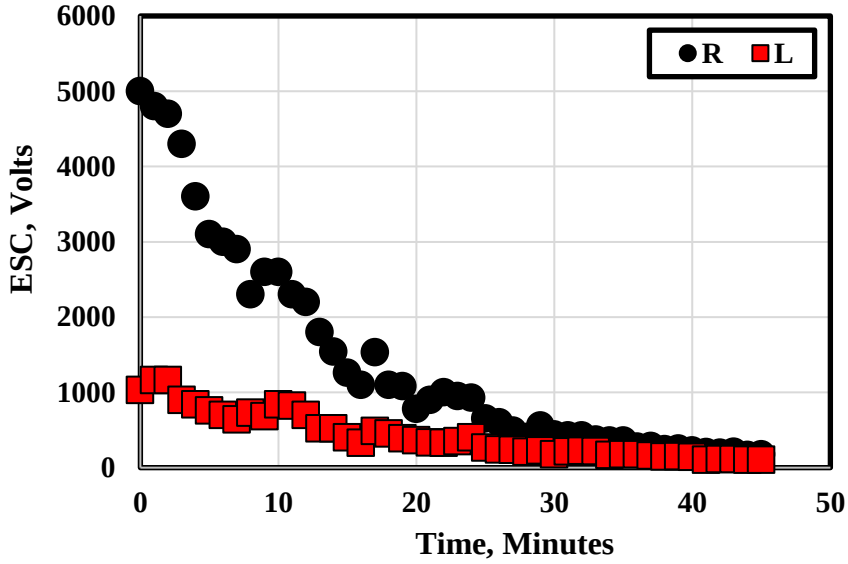


Fig. 4 ESC generated on the surface of the lenses of eyeglasses versus time.

The highest ESC generated on the surface of the lenses of goggles (4, 5) was recorded for that being rubbed by textile that is used to clean the lens, Fig. 6, where the values reached 1870 volts. The lowest values were observed for water vapor. The same trend was observed for goggles (6, 7, and 8) with relatively lower values of ESC. Goggles (9, 10) displayed the highest positive ESC where lens rubbed by textile and paper gained 3440 and 3055 volts respectively, Fig. 8. The goggles (11, 12 and 13) showed a negative ESC down to -2000 volts

displayed by rabbit fur rubbing followed by textile, paper, water vapor, and cotton, Fig. 9. Lenses without rubbing showed the lowest values. The materials of those goggles should be selected carefully and be recommended.

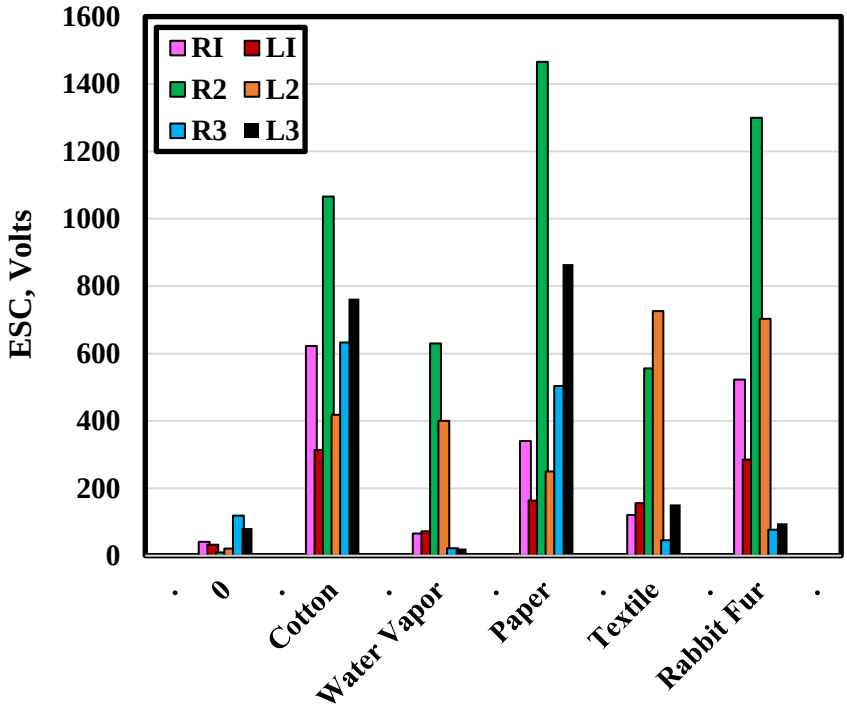


Fig. 5 ESC generated on the surface of the lenses of goggles after rubbing by different materials.

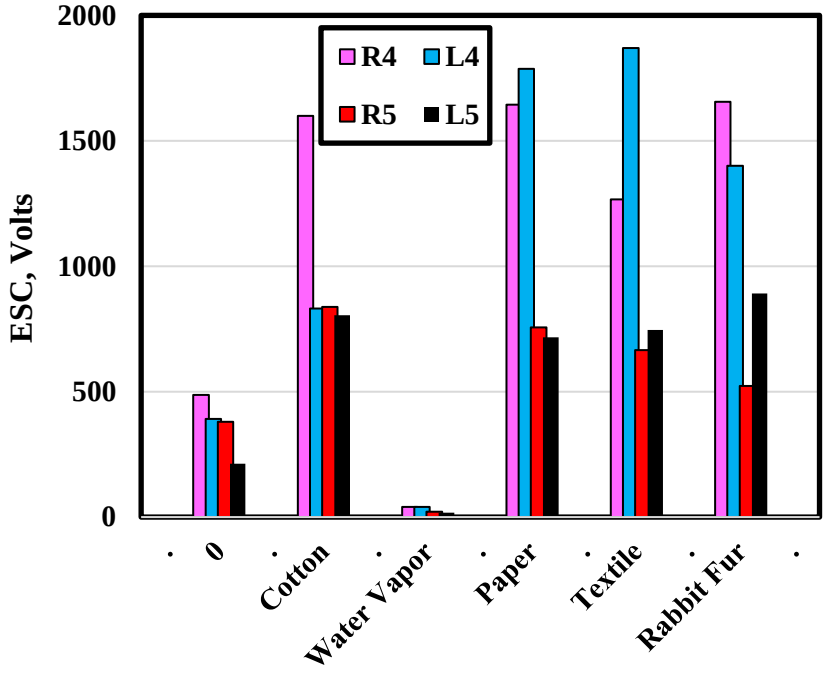


Fig. 6 ESC generated on the surface of the lenses of goggles after rubbing by different materials.

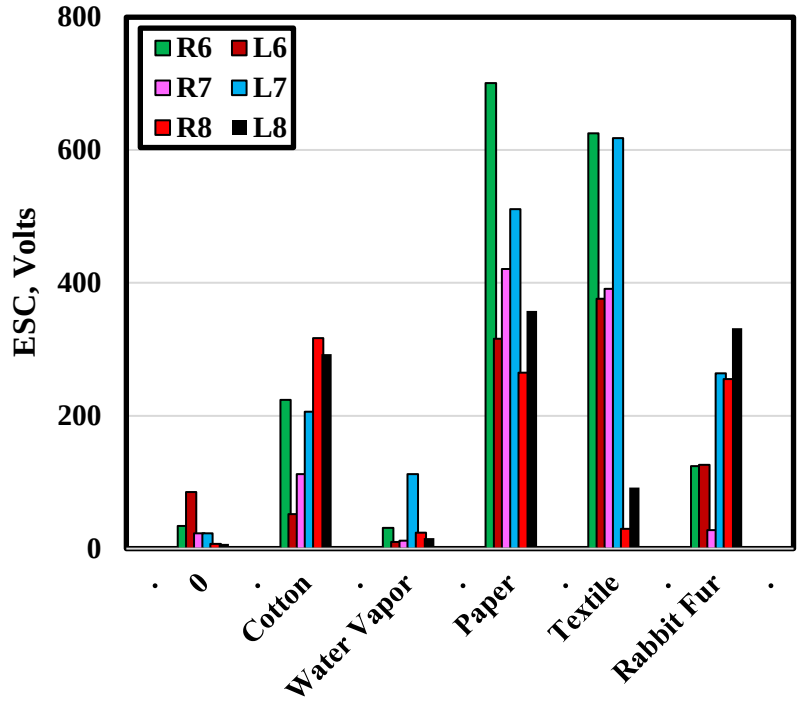


Fig. 7 ESC generated on the surface of the lenses of goggles after rubbing by different materials.

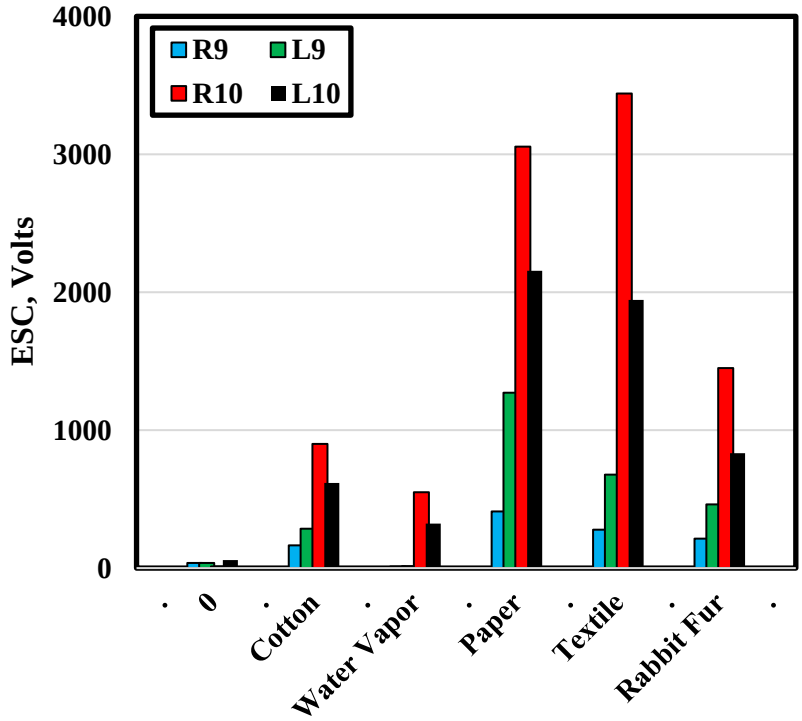


Fig. 8 ESC generated on the surface of the lenses of goggles after rubbing by different materials.

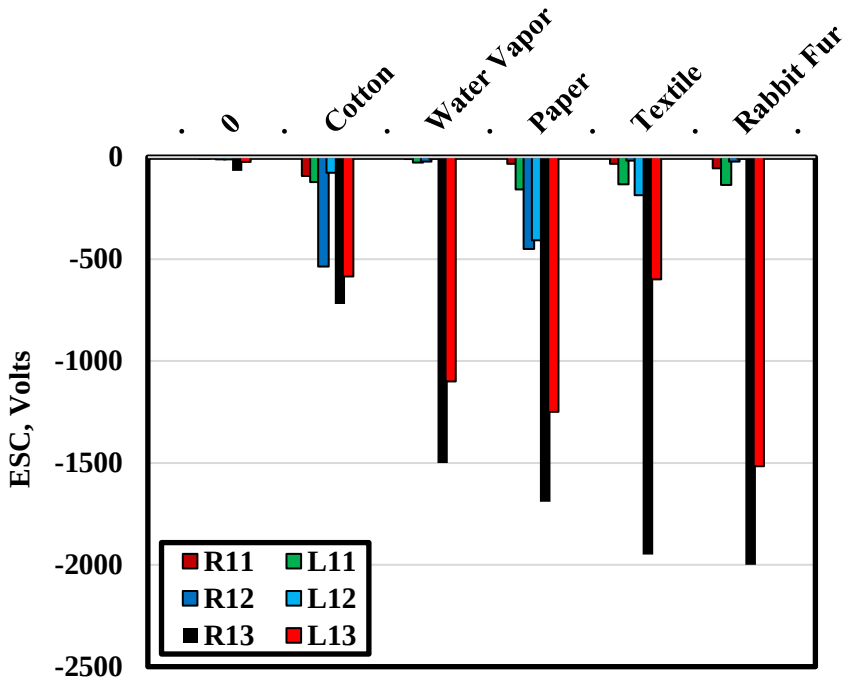


Fig. 9 ESC generated on the surface of the lenses of goggles after rubbing by different materials.

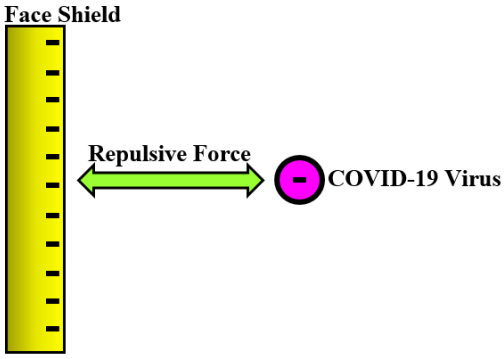


Fig. 10 Illustration of the repulsive force between the face shield and negatively charged viruses.

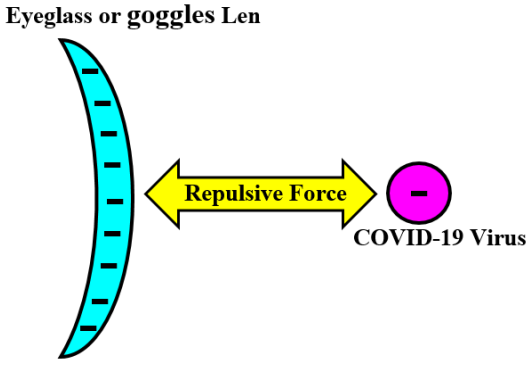
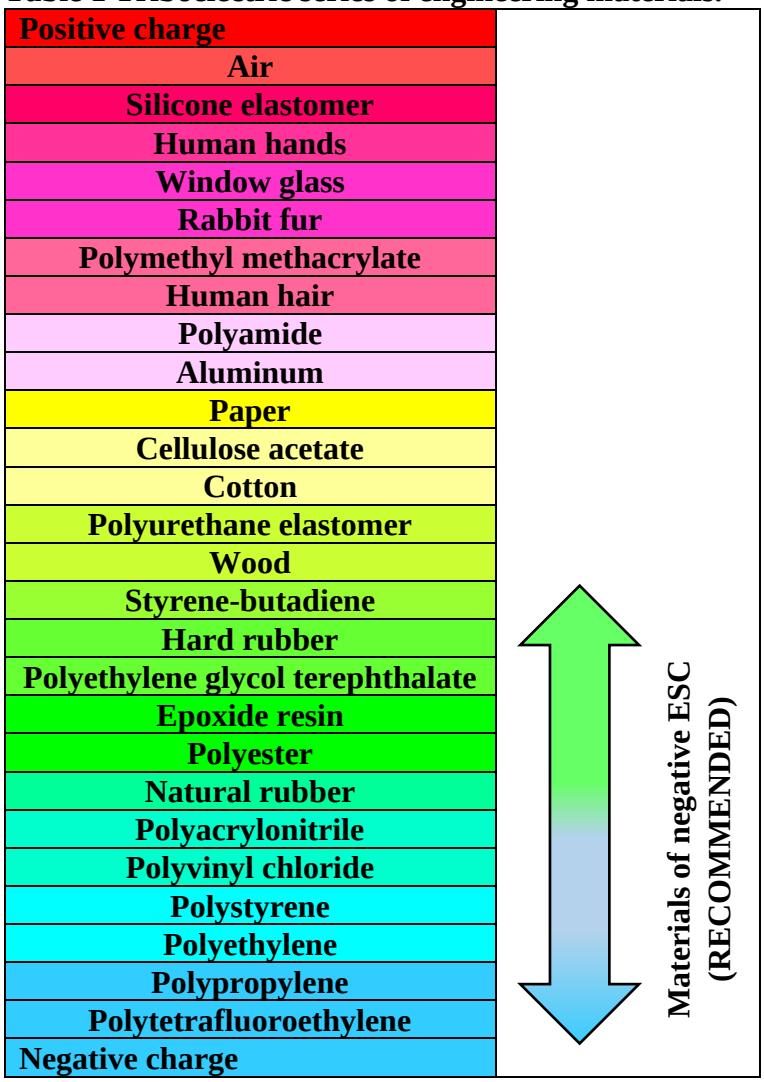


Fig. 11 Illustration of the repulsive force between the eyeglass lens and negatively charged viruses.

Usually, Face shields, eyeglass, and goggles are used to cover the face of the wearer. It is used in conjunction with other personal protective equipment. It is proposed that the outer face shield must have negative ESC so that a repulsive force between the negatively charged viruses and the face shields could be generated. Besides, the contact between the face shield and the air stream would cause negative charge on the face shield, Figs. 10, 11. Having a negatively charged outer layer of the face shield may be the correct choice. It will help repel viruses away from the wearer of the face shield. If the material of the face shield has positive ESC, it will only attract viruses either towards the shield or towards

the face of the wearer. Based on that mentioned above, it is recommended to select such materials that gain strong negative ESC.

Table 1 Triboelectric series of engineering materials.



Generation of ESC from contact and separation as well as sliding of materials is defined as triboelectrification. The engineering materials develop ESC during contact and sliding. The magnitude and polarity of the charge depend on the type of material. Engineering materials are arranged in the triboelectric series, where the higher positioned materials acquire a positive ESC when being rubbed with or when they come in contact with a material at a relatively lower position in the series, [23]. Table 1 shows the triboelectric series of some of the engineering materials. The materials that are in green and blue colors are recommended to be used due to their tendency of gaining a negative charge that can repel the negatively charged viruses away. In the condition of using materials of positive charge, they should be coated by materials of negative charge.

CONCLUSIONS

1. The face shield, made of PP, generated negative ESC that decreased with increasing the time. ESC recorded higher values for face mask and face shield together.

2. The lenses of goggles and eyeglasses for health care workers should be made of materials that gain negative ESC. It was found that the deviation in the values of the ESC generated from the two lenses was significant.

3. Among the thirteen goggles, only three types showed negative ESC displayed by rabbit fur rubbing followed by textile, paper, water vapor and cotton. Lenses without rubbing showed the lowest values. The materials of those goggles can be recommended.

4. Having negatively charged outer layer of the face shield may be the correct choice. It will help repel viruses away from the wearer of the face shield.

5. It is recommended to select the materials that gain strong negative ESC.

REFERENCES

1. Brown, R. C., "Effect of Electric Charge in Filter Materials", Filtration and Separation, January/February 1989, pp. 46 –- 51, (1989).

2. Al-Qaham, Y., Mohamed M. K., and Ali. W. Y., "Electric Static Charge Generated From the Friction of Textiles", Journal of the Egyptian Society of Tribology, EGTRIB, Vol. 10, No. 2, pp. 45 - 56, (2013).

3. Shivangi N., Mukherjee R., and Chaudhuri B., "Triboelectrification: A review of experimental and mechanistic modeling approaches with a special focus on pharmaceutical powders", International journal of pharmaceutics, Vol. 510, No. 1, pp. 375 - 385, (2016).

4. Ali A. S., "Triboelectrification of Synthetic Strings", Journal of the Egyptian Society of Tribology, EGTRIB, Vol. 16, No. 2, pp. 26 - 36, (2019).

5. Pan S. and Zhang Z., "Fundamental theories and basic principles of triboelectric effect: a review." Friction, Vol. 7, No. 1, pp. 2 - 17, (2019).

6. Haiyang Z., "Quantifying the triboelectric series", Nature communications, Vol. 10, No. 1, pp. 14 - 27, (2019).

7. Burgo. T. A., Galembeck F. and Pollack G. H., "Where is water in the triboelectric series?", Journal of Electrostatics, Vol. 80, pp. 30 - 33, (2016).

8. Gooding D. M. and Kaufman G. K., "Tribocharging and the triboelectric series." Encyclopedia of Inorganic and Bioinorganic Chemistry, pp. 1 - 14, (2011).

9. Benson, Stacey M., Debra A. Novak, and Mary J. Ogg., "Proper use of surgical N95 respirators and surgical masks in the OR", AORN journal, Vol. 97, No. 4, pp. 457 - 470, (2013).

10. Zhang R., Li Y., Zhang A. L., Wang Y. and Molina M. J., "Identifying airborne transmission as the dominant route for the spread of COVID-19", Proceedings of the National Academy of Sciences, (2020).

11. World Health Organization., "Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations: scientific brief, 27 March 2020", No. WHO/2019-nCoV/Sci_Brief/Transmission_modes/2020.1., World Health Organization, (2020).

12. Chellamani K. P., Veerasubramanian D., and Balaji R. S. V., "Surgical face masks: manufacturing methods and classification.", Journal of Academia and Industrial Research, Vol. 2, No. 6, pp. 320 - 324, (2013).

13. Lipp A., and Peggy E., "Disposable surgical face masks for preventing surgical wound infection in clean surgery", Cochrane Database of Systematic Reviews, No. 1, (2002).
14. Greenhalgh T., Schmid M. B., Czypionka T., Bassler D., Gruer L., "Face masks for the public during the covid-19 crisis" Bmj, 369, (2020).
15. World Health Organization, "Rational use of personal protective equipment (PPE) for coronavirus disease (COVID-19): interim guidance, 19 March 2020", No. WHO/2019-nCoV/IPC PPE_use/2020.2. World Health Organization, (2020).
16. Roberge R. J., "Face shields for infection control: A review.", Journal of occupational and environmental hygiene, Vol. 13, No. 4, pp. 235 - 242, (2016).
17. Renyi Z., "Identifying airborne transmission as the dominant route for the spread of COVID-19", Proceedings of the National Academy of Sciences, (2020).
18. World Health Organization., "Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations: scientific brief, 27 March 2020", No. WHO/2019-nCoV/Sci_Brief/Transmission_modes/2020.1, World Health Organization, (2020).
19. Mercedes Z., "Quantitative nanoscale electrostatics of viruses", Nanoscale, Vol. 7, No .41, pp. 17289 - 17298, (2015).
20. Janssen L. L., "Efficiency of degraded electret filters: Part I. Laboratory testing against NaCl and DOP before and after exposure to workplace aerosols", Journal of the International Society for Respiratory Protection, Vol. 20, pp. 71 - 80, (2003).
21. Janssen, L. L., "Efficiency of degraded electret filters: Part II. Field testing against workplace aerosols", J. Int. Soc. Respir. Prot, Vol. 20, pp. 81 - 90, (2003).
22. Wallace L., Fong W. and Sun Q., "Electrostatic Charged Nanofiber Filter for Filtering Airborne Novel Coronavirus (COVID-19) and Nano-aerosols.", Separation and Purification Technology, (2020).
23. Diaz A. F., and Felix-Navarro R. M., "A semi-quantitative tribo-electric series for polymeric materials: the influence of chemical structure and properties.", Journal of Electrostatics, Vol. 62, No. 4, pp. 277 - 290, (2004).