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PROPER MATERIAL SELECTION OF MEDICAL SAFETY GOGGLES

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ABSTRACT
The present work aims to select the proper materials of goggles to provide protection from newly COVID-19 viruses. Electrostatic charges (ESC) generated on the surface of polymeric materials during contact and separation as well as sliding can be used to repel the negatively charged viruses like COVID-19 out of the eyes so that the goggles can protect the eyes from infection risk. ESC generated on the surface of the medical safety goggles is measured to determine their sign and magnitude and investigate their performance in protection of the wearer from viruses. Two type of medical safety goggles were used the first was polymethyl methacrylate (PMMA), while the second was polyvinyl chloride (PVC). They were rubbed by different materials.

It was found that PMMA goggles rubbed by different materials generated positive ESC so that the application of such material should be limited. It is recommended that, the material of goggles should be in the lower part of the triboelectric series that includes PE, PP and PVC, because they gain strong negative ESC able to repel the viruses away of the wearer. Besides, the negative ESC generated on the surface of goggle can ionize the air in the front of the goggle to be negatively charged and offer region of negative ESC and electric field.

KEYWORDS
Protective, equipment, health care, COVID-19, medical safety goggles.

INTRODUCTION
Viruses are coated with proteins. They contain DNA or RNA, [1, 2], that provides negative charge to the virus. The charge of the virus depends upon the total charges of the genetic material and protein. The electric field alters the dipole of the protein of the virus, [3]. The positive salt ions can diffuse into the protein of the viruses, inactive and disintegrate. The crystal structure of SARS-CoV N-NTD (lumen) shows localized segregation of positive and negative charges, [4]. It was revealed that residual of net negative charge can exist in the core of the coronavirus, [5].

Cloth that could inactivate or repel coronaviruses such as COVID-19 was developed, [6]. The material of the cloth generates electric fields across the surface of the fabric that disables the performance of bacteria or viruses on the cloth. Spots of silver and zinc are printed on polyester textile, where generate a weak electric field that zaps viruses on the surface. Blend of woven cotton and silk or polyester chiffon as electrostatic layers, [7], is used to increase the filtration efficiency of the cloth.

Polymeric medical protective equipment of people working in the medical care are easily triboelectrified. They gain ESC from rubbing each other, where the electric field is generated can attract or repel the electrically charged particles, [8]. It is recommended to use surgical masks because COVID-19 is a respiratory disease, [9 - 15]. ESC generated on the surfaces of the surgical masks can make benefit from ESC to capture or repel the viruses, [16]. The spread of COVID-19 can occur via airborne routes, [17 - 19]. It was proved that most viruses have negative ESC, [20, 21], including COVID-19, [22]. It is vital to know the sign and intensity of ESC generated on the surfaces of the medical protective equipment.

The performance of the facemask was enhanced by using polymeric fibers, [23]. It was proved that the negative ESC generated on the surface of the facemask made of PP fibers can ionize the air to be negatively charged. This behavior provided space of negative ESC in front of the mask, where repulsive force is generated to push away COVID-19 viruses of negative charge from the facemask. It is recommended that actively negative charged polymers such as PP and Polytetrafluoroethylene (PTFE) to increase the negative ESC of the air during inhalation and exhalation from the mouth and nose.

Medical safety goggles are usually made of polycarbonate (PC) and polyvinyl chloride. PC is located in the positive section of the triboelectric series, while PVC is in the negative section, [24 - 25]. It means that they obtain a tendency to gain positive and negative charges respectively when they contact or rub other materials.

The present study discusses the effect of triboelectrification in selecting the proper materials of the medical safety goggles to protect the eyes from viruses.

EXPERIMENTAL

The function of the medical safety goggles is to protect eyes from infection. It is necessary to select proper materials for the goggles. In the present work, experiments were carried out to measure the ESC generated from rubbing goggles by different materials. Two types of goggles made of PVC and PMMA were rubbed by paper, rabbit fur, latex and nitrile. Besides, different types of textiles such as cotton, wool, polypropylene (PP), polyethylene (PE), polyester (PET), polyurethane (PU), polyamide (PA), polymethyl methacrylate (PMMA) and silk were tested as rubbing materials. The surface of the tested goggles was rubbed by skin, water and steam vapors, water wet and were exposed to air and sunshine. The sign and magnitude of the ESC were measured. The tested surfaces were washed by detergent and dried by air before the test. Surface DC voltmeter was used to measure the ESC, Figs. 1 - 3.

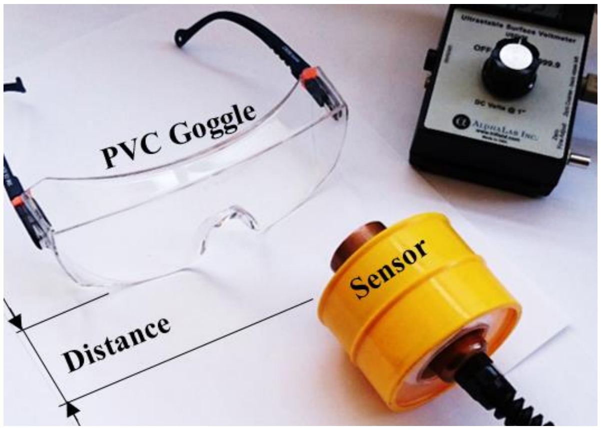

Fig. 1 PVC goggle.

Fig. 2 PMMA goggle.

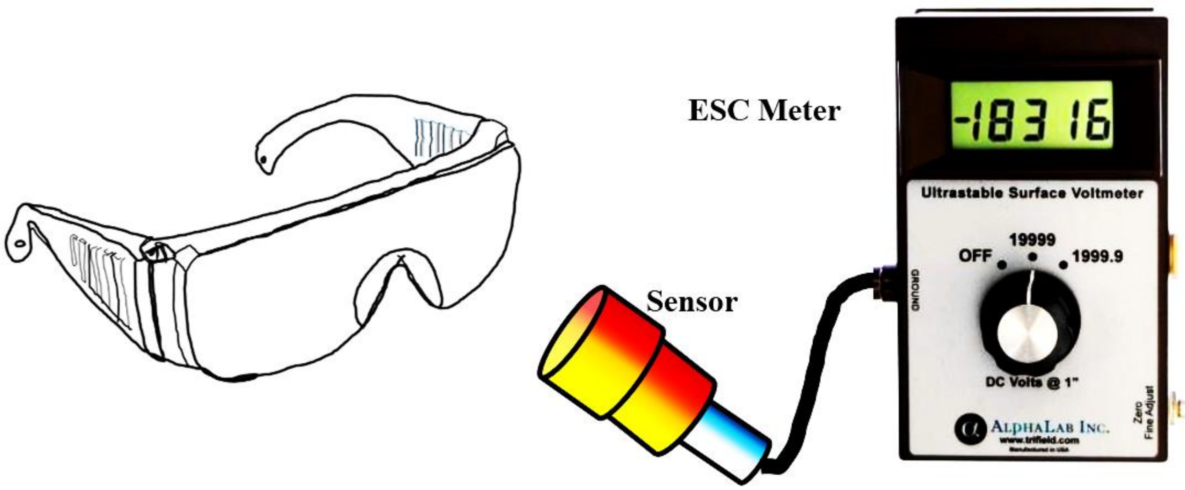

Fig. 3 Test method.

RESULTS AND DISCUSSION

The measurement of ESC generated on the outer surface of the tested PMMA goggle rubbed by PP, PE and PET is shown in Fig. 4. Before the test, the goggle was washed by detergent and air dried. Then ESC was measured at distance from the lens ranged between 25 and 300 mm. It was found that goggle rubbed by PP displayed the highest value of ESC that reached +11000 volts. ESC decreased with increasing the distance from the lens to approach zero value at 300 mm. The value of ESC decreased for PE and PET. Goggle cleaned by detergent without rubbing showed negative ESC. It is clearly known that health care workers should use goggles for eye protection from infection. This can be achieved when the lenses are made of materials that gain negative ESC. It was observed that the values of ESC generated on the surface of the PMMA goggle were relatively high of positive charge. This type of goggle cannot be recommended to be used and should be limited.

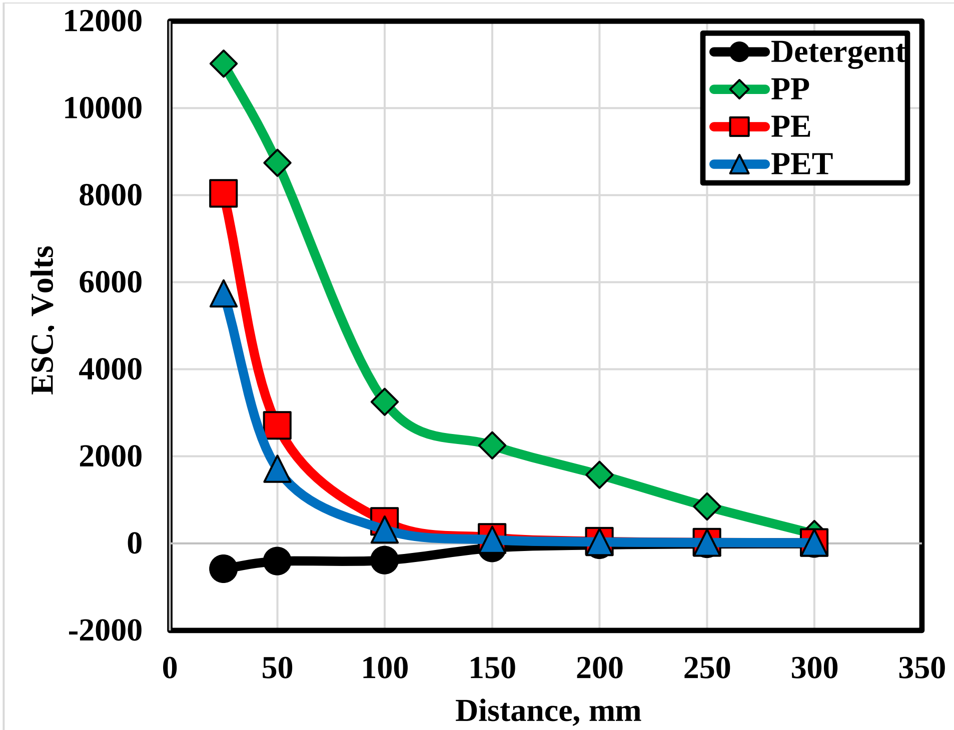

Fig. 4 ESC generated on the surface of the PMMA goggles after rubbing by PP, PE and PET.

The same trend was observed when the goggle was rubbed by cotton, paper and silk, Fig. 5. Goggle rubbed by cotton and paper exhibited the highest values of ESC, while silk recorded very low values of ESC. The highest value of ESC reached +11000 volts presented by cotton and paper. ESC generated on the surface of the PMMA goggles by latex, nitrile and polyethylene gloves versus distance is shown in Fig. 6. Nitrile recorded the highest ESC followed by PE and latex, where the maximum value reached +17000 volts. Figure 7 shows the values of ESC generated on the surface of the PMMA goggles rubbed by skin, grounded skin, water and steam vapor and water wet versus distance. Skin rubbing represented the highest negative ESC (-1350 volts) followed by grounded skin (-950 volts). Water vapor, steam vapor and water wet surfaces recorded positive values ESC of 250, 200 and 50 volts respectively. ESC generated on the surface of the PMMA goggles rubbed by PP, PU, PA and exposed to sunshine versus distance is shown in Fig. 8. It is observed that rubbing the lens of goggles by polymeric textiles generates relatively higher values of ESC that represents higher risk of attracting viruses into the goggle surface. The negative ESC generated electric field in front of the goggles, where the length of its effect may extent to 250 mm.

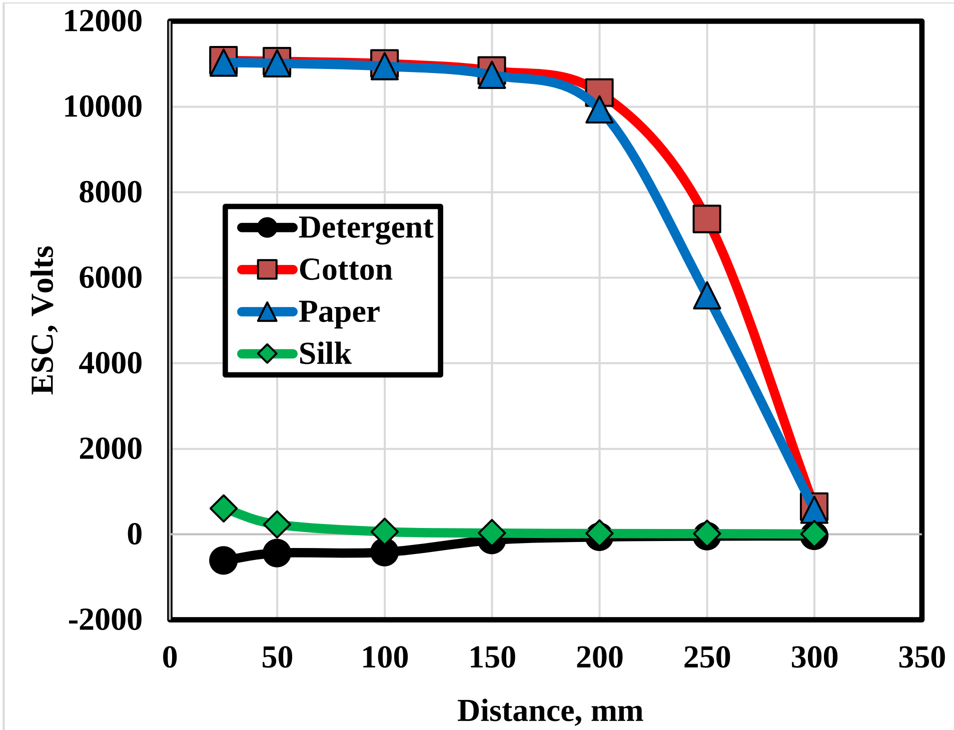

Fig. 5 ESC generated on the surface of the PMMA goggles rubbed by cotton, paper and silk versus distance.

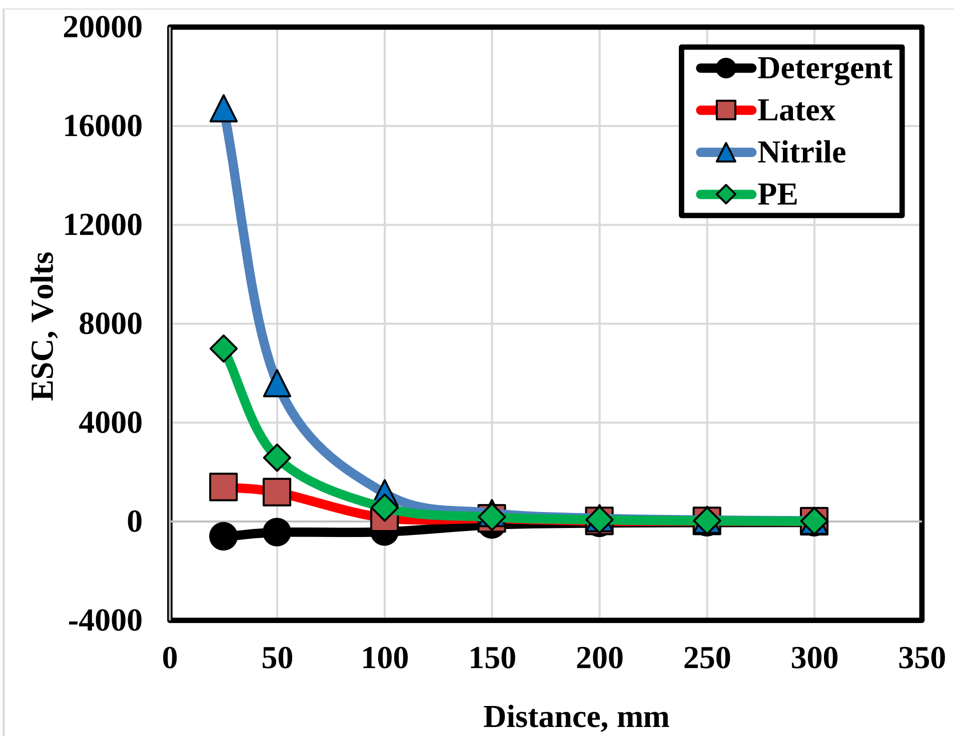

Fig. 6 ESC generated on the surface of the PMMA goggles by latex, nitrile and polyethylene gloves versus distance.

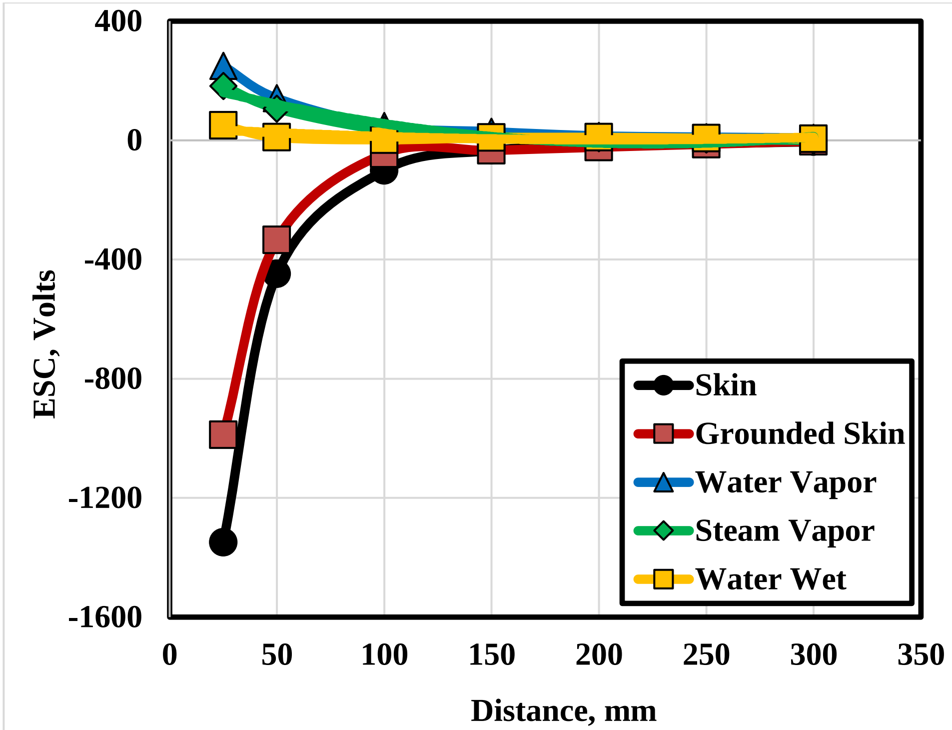

Fig. 7 ESC generated on the surface of the PMMA goggles rubbed by skin, water and steam vapor versus distance.

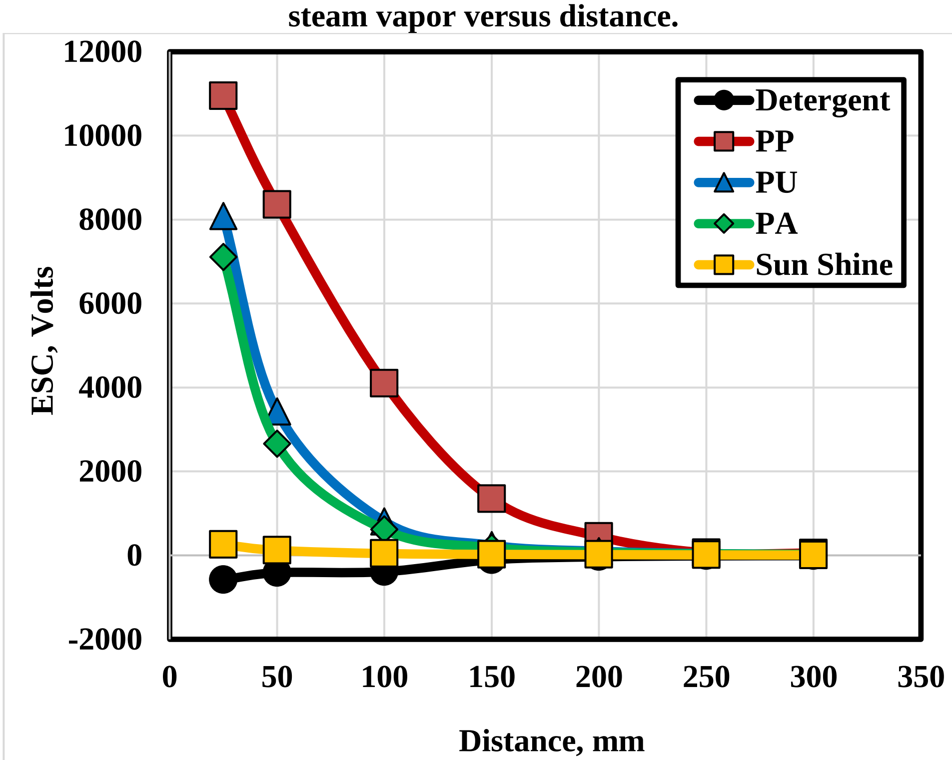

Fig. 8 ESC generated on the surface of the PMMA goggles rubbed by PP, PU, PA and exposed to sunshine versus distance.

Medical safety goggles should cover the eye area and protect from germs and respiratory viruses. They can minimize the spread of infections at health care institutions and hospitals. There is a great need to develop the goggles that provide protection from newly Covid 19 viruses. It is needed to use the electrostatic properties of polymeric materials to repel the negatively charged viruses out of the eyes. Figure 9 illustrates the distribution of ESC in front of the goggle. The positive ESC is represented by the red color, while the negative ESC is shown in green. Considering the safety of the medical protective equipment, the material of goggles should be in the lower part of the triboelectric series that includes PE, PP and PVC. Then triboelectrified, these materials possess aggressive negative charge ESC and can guarantee the repulsion of the viruses away of the wearer. When the negative ESC generated on the surface of goggle they can ionize the air to be negatively charged, Fig. 10, offering space of negative ESC and electric field in front of the goggle for a distance up to 200 mm. It is expected in this space, that repulsive force is generated, where COVID-19 viruses of negative charge are repelled away from the facemask.

Sliding as well as contact and separation of polymeric materials generate ESC. Each material gains charge of opposite or negative polarity. Materials are ranked in the triboelectric series according to their relative polarity of ESC, [32]. The materials of positive charge are in higher position when being rubbed by other material at lower position, Table 1. The ESC polarity and intensity gained by the materials can be determined by means of the triboelectric series. It is recommended that the material of the lens of goggle should generate negative ESC to repel the negatively charged viruses. In addition to that, the impact of air stream on the lens generates negative charge on the lens. Having a negatively charged outer surface of the lens may be the correct choice.

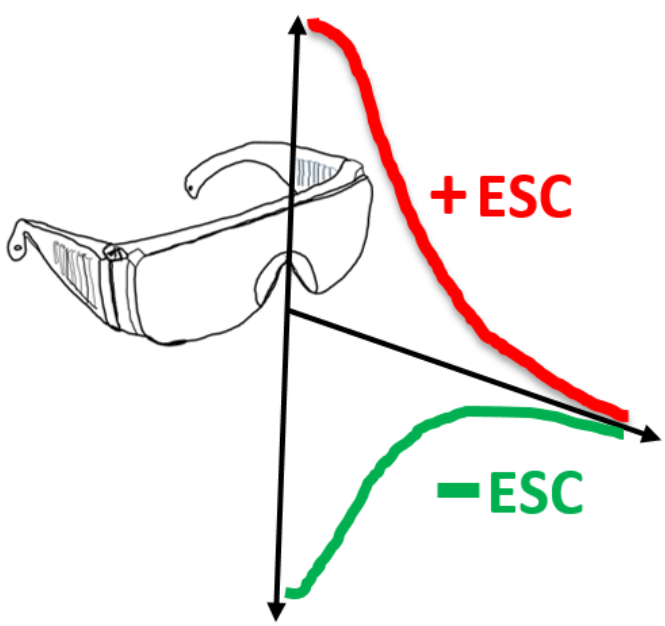

Fig. 9 Representation of ESC distribution in front of the goggle.

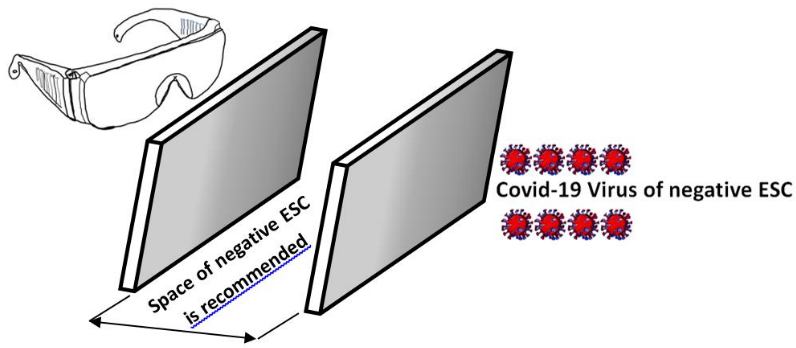

Fig. 10 The generation of the space of negative ESC in front of goggles to generate repulsive force to repel the negatively charged negative viruses.

Table 1 Triboelectric series of engineering materials.

Positive charge	
Air	
Silicone elastomer	
Human Skin	
Rabbit fur	
Polymethyl methacrylate (PMMA)	
Polyamide (PA)	
Wool	
Silk	
Paper	
Cellulose acetate	
Cotton	
Polyurethane elastomer (PU)	
Wood	
Styrene-butadiene	
Hard rubber	
Polyester (PET)	
Polycarbonate (PC)	**Materials of negative ESC (RECOMMENDED)**
Polystyrene (PS)	
Natural rubber	
Polyacrylonitrile (PAN)	
Polyethylene (PE)	
Polypropylene (PP)	
Polyvinyl chloride (PVC)	
Polytetrafluoroethylene (PTFE)	
Negative charge	

The measurement of ESC generated on the lens of PVC goggle is shown in Figs. 11 – 17. ESC generated on the surface of the PVC tested goggles rubbed by cotton, wool, paper and exposed to air stream versus time is shown in Fig. 11. Because PVC is considered as negative charged material, the negative ESC generated on the surface of lens of the goggle

can ionize the air to be negatively charged. Cotton caused the highest values if ESC followed by wool and paper. The negative ESC provided region of negative electric field in front of the goggle and could generate repulsive force that repels COVID-19 viruses of the negative charge away from the goggle. ESC slightly decays with time. The tested goggle rubbed by PET, rabbit fur and PMMA shows different trend with time, Fig. 12, where PMMA recorded the highest negative ESC.

ESC generated on the surface of the PVC goggles rubbed by different materials as function of the distance from the lens of the goggle are shown in Figs. 13 – 16. Positive charged materials that are lying the upper zone of triboelectric series generated negative ESC on the lens of the tested goggles, while that of negative ESC caused positive charge. When air rubs the lens of the goggle, it generates negative ESC because air is in the top of the triboelectic series. Then air in the front of the goggle will be ionized and generated electric field of negative charge. Referring to Table 1 it can be recommended that the materials that are in blue colors are active in gaining negative ESC, so they should be used for the lens of the goggle due to their activity to repel the negatively charged viruses such as COVID-19 away. Intensity of ESC generated on the surface of the PVC goggles after exposing to the air stream of 1.0 m/s velocity versus time at different distance from the lens is presented, Fig. 17. It is clearly seen that, ESC significantly increased with the time, while decreased with increasing the distance from the lens. This behavior can be useful for people actively moving.

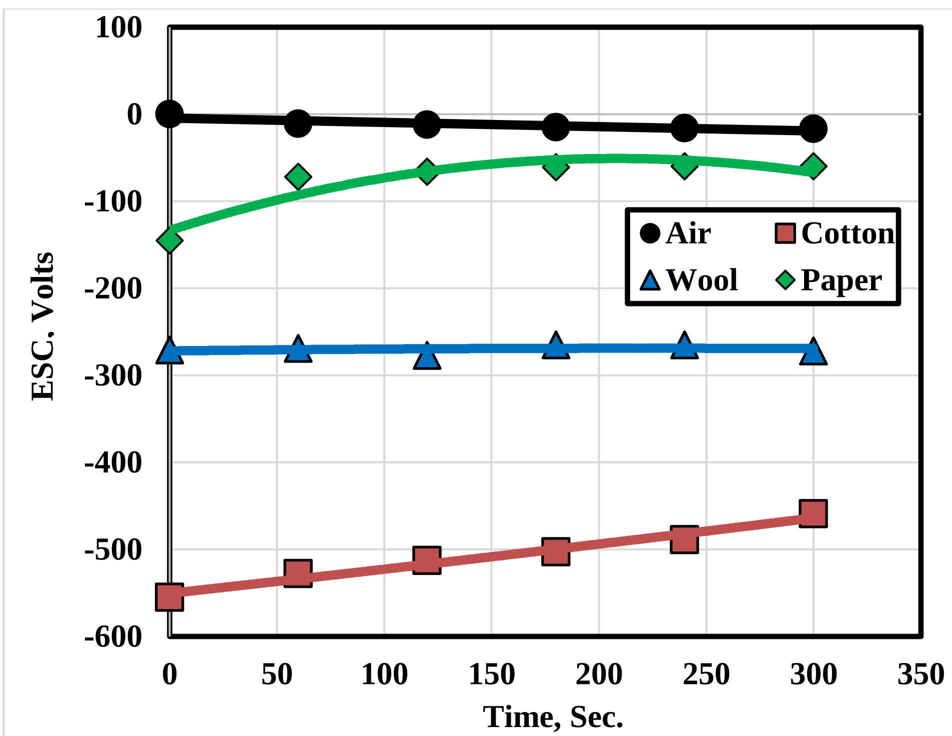

Fig. 11 ESC generated on the surface of the PVC tested goggles versus time.

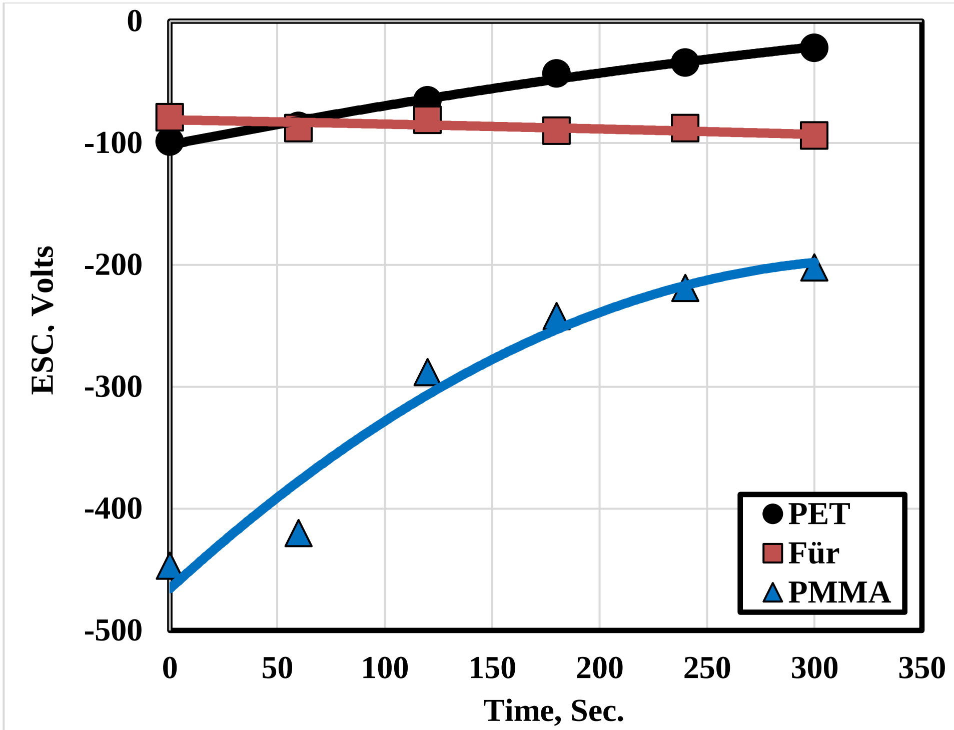

Fig. 12 ESC generated on the surface of the PVC tested goggles versus time.

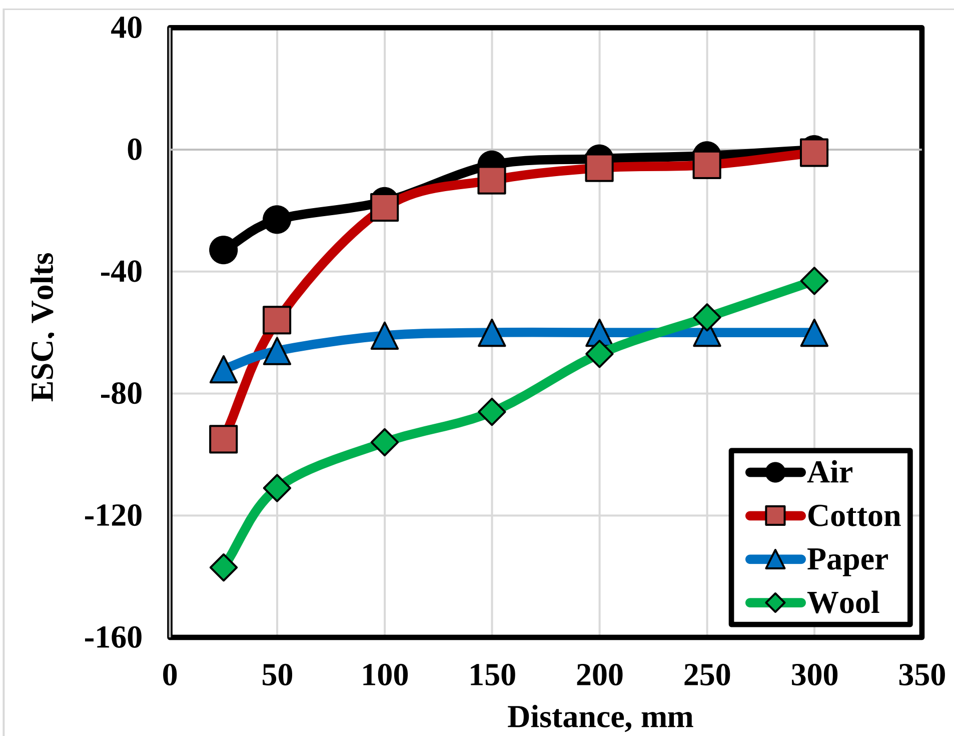

Fig. 13 ESC generated on the surface of the PVC goggles versus distance.

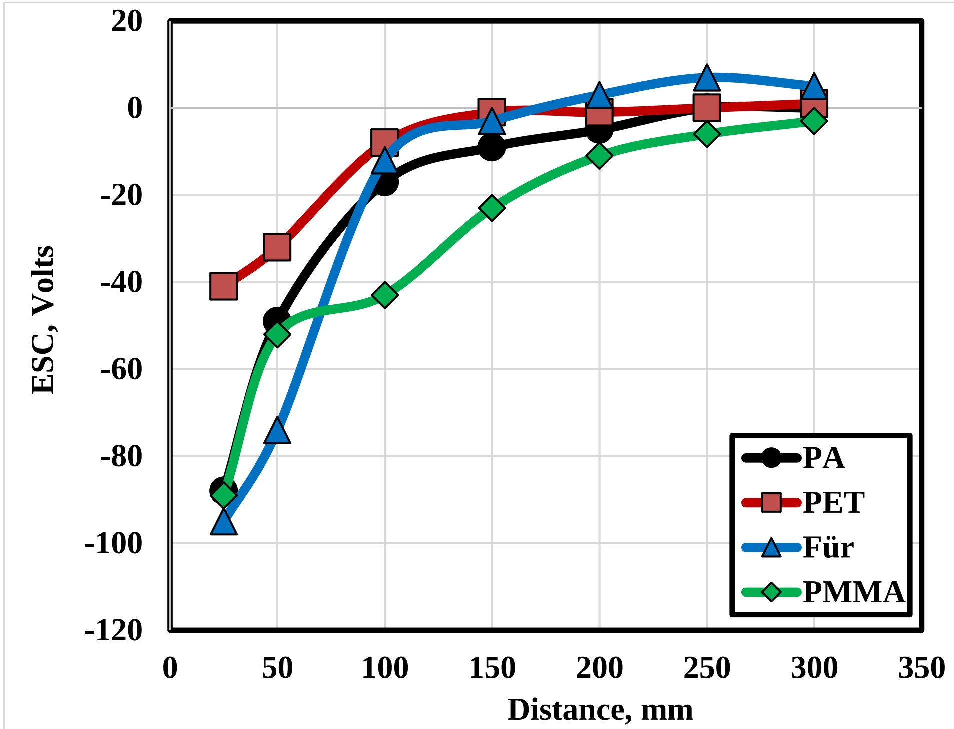

Fig. 14 ESC generated on the surface of the PVC goggles versus distance.

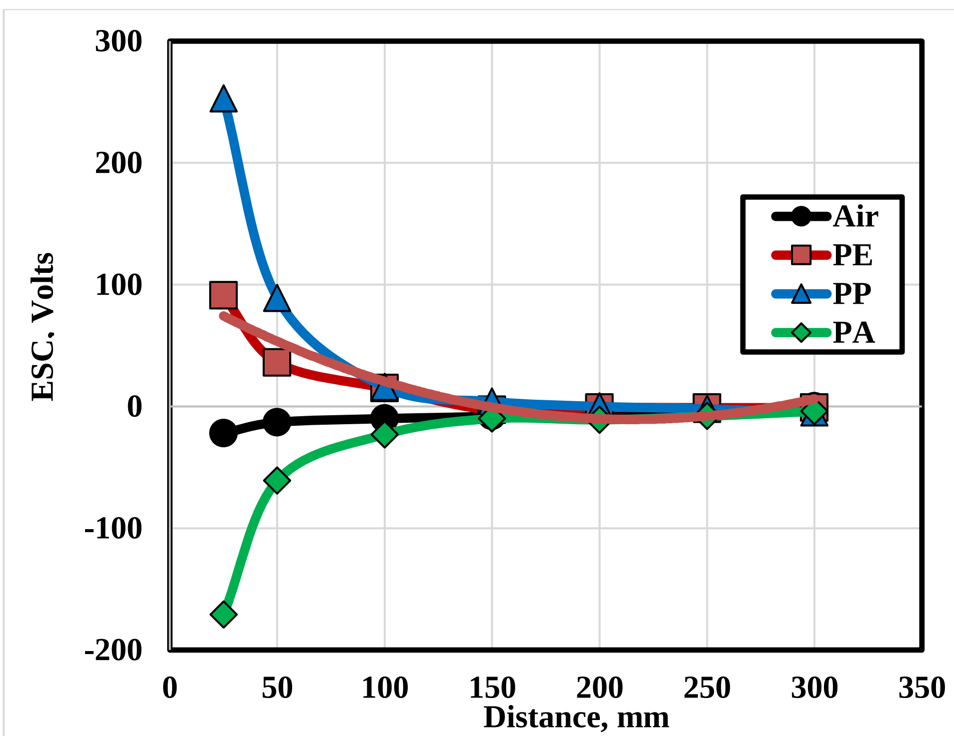

Fig. 15 ESC generated on the surface of the PVC goggles versus distance.

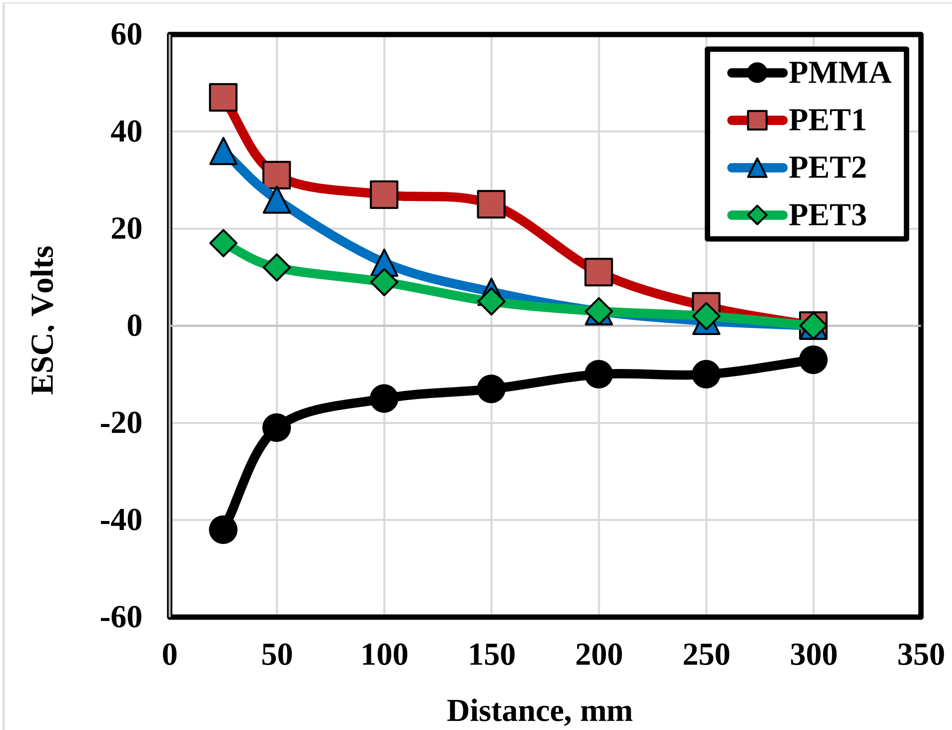

Fig. 16 ESC generated on the surface of the PVC goggles versus distance.

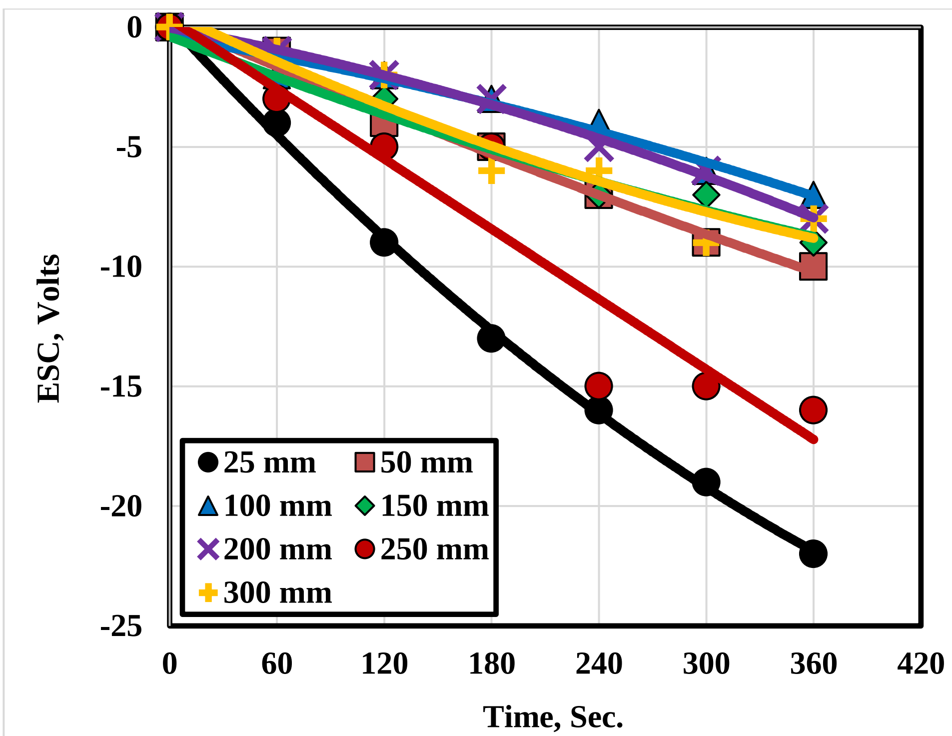

Fig. 17 Intensity of ESC generated on the surface of the PVC goggles at different distance from the lens versus time.

CONLUSIONS

1. Goggle cleaned by detergent without rubbing showed negative ESC.
2. ESC decreased with increasing the distance from the lens to approach zero value at 300 mm.
3. ESC generated on the surface of the PMMA goggle displayed relatively higher values of positive ESC. The use of that type of goggle should be limited.
4. It is commended to generate electric fields in front of the surface of the goggle to repel the viruses of negative charge away.
5. The material of goggles should be selected from those in the lower part of the triboelectric series that includes PE, PP and PVC, where those materials have strong negative ESC to ensure the repulsion of the viruses out of the wearer.
6. The impact of air stream on the lens generates negative charge on the lens.
7. The lens of PVC goggle gained negative ESC generated on its surface when goggles being rubbed by all the materials that are lying above PVC in the triboelectric series.
8. ESC slightly decayed with time.

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