**EGTRIB Journal**

**JOURNAL OF**
**THE EGYPTIAN SOCIETY OF TRIBOLOGY**
***VOLUME 19, No. 2, April 2022, pp. 1 - 11*** **ISSN 2090 - 5882**

***(Received January 12. 2022, Accepted in final form February 26. 2022)*** **jest.journals.ekb.eg**

# INCREASING THE EFFICIENCY OF THE MEDICAL FACEMASK TO RESIST COVID-19

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## ABSTRACT

**The present work aims to increase the efficiency of the medical facemask to resist covid-19 by proposing the separation of the three layers of polypropylene (PP) by fibers and beads of polymeric materials. This procedure can increase the negative electrostatic charge (ESC) generated from the triboelectrification of the PP layers of the medical facemask by the air friction when it goes through to repel the negative charged viruses such as Covid-19 out of the facemask. Besides, ESC increase can lead to the increase of the electric field in front of the facemask enhancing its function to repel the viruses. The role of separating the PP layers by polyester (PET) fibers as well as glass, polycarbonate (PC) and polystyrene (PS) beads on the magnitude of the ESC is investigated.**

**The observations of the present experiments showed that inserting fibers or beads of different materials between the PP layers increased both the air gap between them and the surface area of layers. When the air passed through the PP fibers they get negatively charged, where the magnitude of ESC increased as the triboelectried area increased. The presence of air gap increased the ability of air to be ionized and the electric field might be generated. When the magnitude of ESC increases, the electric field increases, where its ability to repel negative charged viruses increased and prevented them from going back during inhalation. As result of that, the efficiency of the PP medical facemask to resist covid-19 increased.**

## KEYWORDS

**Polypropylene facemask, COVID-19, polyester fibers, glass and polymeric beads.**

## INTRODUCTION

**Increasing the efficiency of medical facemasks to protect the wearer from viruses including COVID-19 of negative charge has recently great importance. Few modifications were tested to increase ESC generated from the friction of air passing through PP layers of the facemask. Because PP is actively charged negatively, it generates negative ESC, [1, 2]. It is known that protection from viruses necessitates filtration fineness lower than 0.01 µm fineness. It was revealed that when PP layers were separated by polymeric nets such as PE and PP, the**

**intensity of ESC increased because the surface area activated by ESC increased. It was suggested the the electric field induced inside the gap increased, [3]. Besides, fibrous PET strings weaved in PP layers caused remarkable increase in ESC. Electrostatic charged microfibers are extensively used in facemasks, [4 - 10]. Medical facemasks of non-woven PP are widely used to resist the spread of Covid-19. It is clear that the contact between the mask and the skin generates ESC of double layers of positive and negative charge on the skin and PP mask respectively, [11 - 13]. It was revealed that the majority of viruses has negative charge, [14], including Covid-19. Based on that fact, it is suggested to increase the negative electric field in front of the facemask to repel the viruses away, [15].**

**It was recommended to manufacture the medical protective equipment, facemask, eyeglasses and goggles from PP, polyethylene (PE) and polyvinyl chloride (PVC) to be negatively triboelectrified, [16 - 18], while application of materials of positive ESC such as silk, cotton, polymethyl methacrylate (PMMA) and polyamide (PA) should be limited. The presence of air gap helps the ESC to ionize the air and provide space of negative electric field in front of of the facemask. In hospitals, it was recommended to manufacture the shoes and shoe covers from PP and PE respectively. In addition to that, PE gloves are recommended due to their electrification by relatively strong negative ESC, [19, 20]. While, PP was proposed for outer layer of the facemask and PMMA microfibers were was used as inner layer to capture the negatively charged viruses like Covid-19, [21].**

**Small air ions were proved to reduce infection and contamination, [22]. When air is bipolar ionized, the body is able to fight disease. Besides, It was suggested that when the surface of the implants was provided by negative charge the osseointegration of titanium biomaterials was developed, [23 - 25], because the negative ESC generated on the surface of dental implant enhanced its osseointegration to the bone due to the fibroblasts inhibition as well as the selective osteoblasts activation.**

**The present work proposes separation of the layers of polypropylene (PP) layers used to manufacture the medical facemask the by fibers and beads of glass and polymeric materials to increase the efficiency of the medical facemask to resist covid-19. It is aimed to increase ESC generated on the surface of the PP layers of the medical facemask, where ESC can repel the negative charged viruses such as Covid-19 out of the facemask.**

## EXPERIMENTAL

**The PP layers of the facemask were separated by inserting polymeric fibers and beads of different diameters, Fig. 1. The order of the distribution of the different tested materials is shown in Fig. 2. Nonwoven PET fibers of 0.1 and 0.2 mm diameter as well as beads of glass, polystyrene (PS) and polycarbonate (PC) of 4.75, 5.2 and 8.0 mm diameters respectively were used in different order, Fig. 3. Nonwoven fibers of PET were used as spacer between PP layers. The experiments were performed by testing the layers of tested mask by exhaling and inhaling ten times, then ESC generated at different distances in front of the tested layers was measured by ultra stable surface DC voltmeter, Fig. 4.**

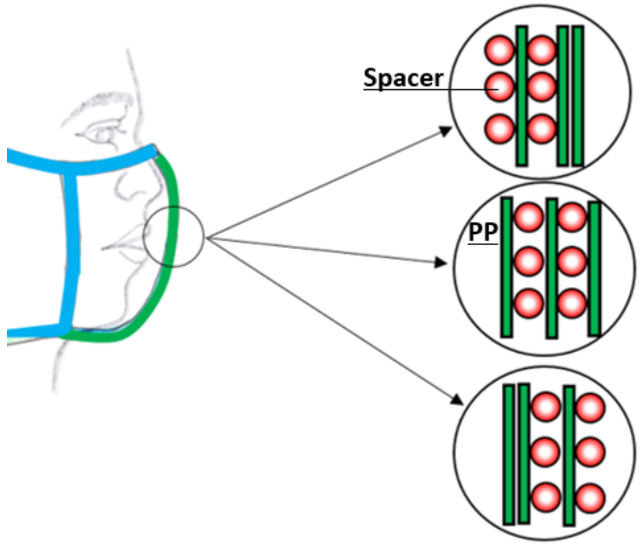



**Fig. 1 The tested arrangement of the facemask.**

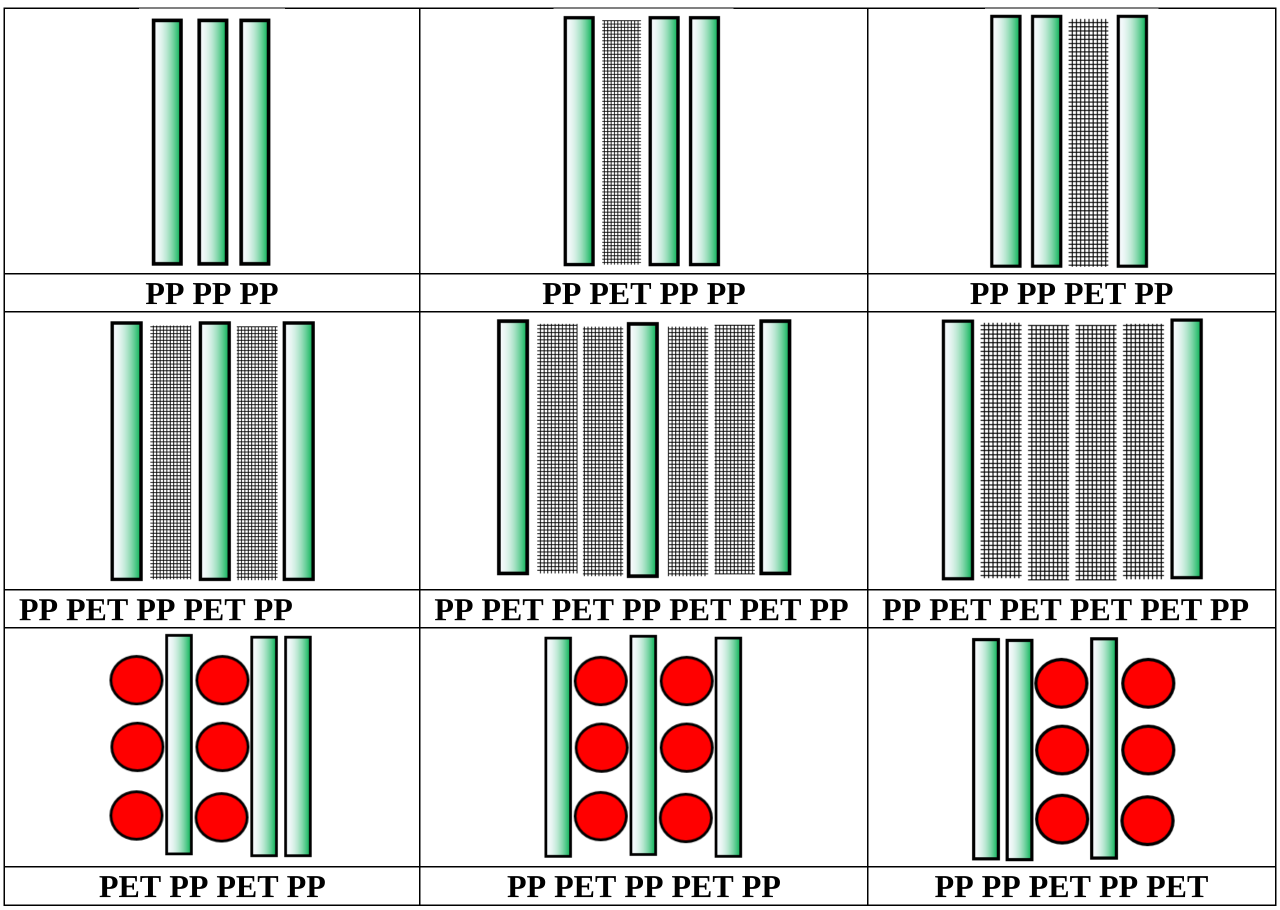
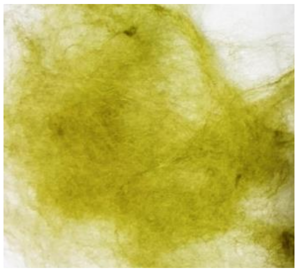



**Fig. 2 The order of the tested materials.**

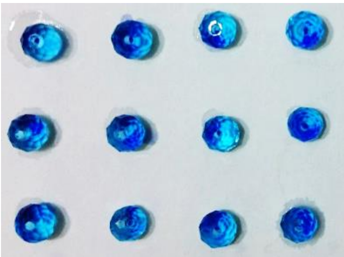
**a. PET (I) Nonwoven of 0.02 mm fiber diameter.**

**b. PET (I).**

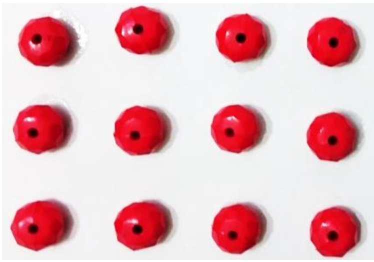
**c. PET (II) Nonwoven of 0.01 mm fiber diameter.**



**d. PET (II).**



**e. Glass beads of 4.75 mm diameter.**



**f. PC beads of 5.2 mm.**

**g. PS beads of 8.0 mm diameter.**

**Fig. 3 The tested materials.**

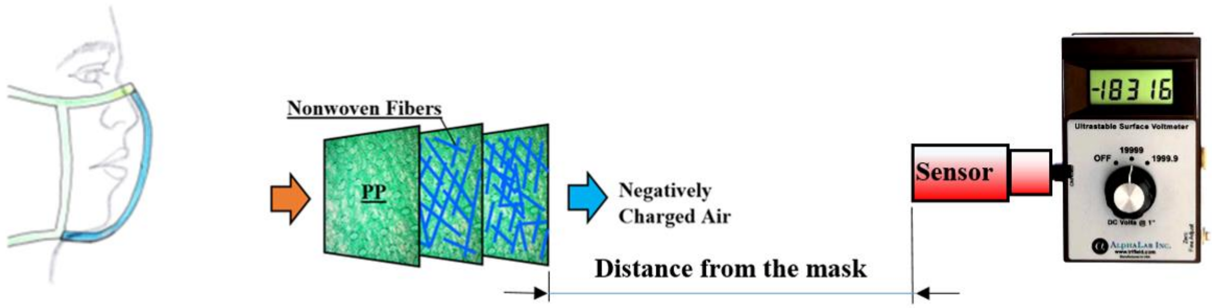



**Fig. 4 Measurement of ESC generated in front of the facemask fitted by nonwoven PET spacer.**

**RESULTS AND DISCUSSION**

**The experiments carried in the present work aim to apply the ESC generated from the triboelectrification of the PP layers of the medical facemask to repel the negative charged viruses such as Covid-19. It is proposed to developing ESC generated on the facemask by introducing air gap between the PP layers. It is thought that the separation of PP layers could increase the intensity of ESC generated by the friction of air stream with PP fibers. Consequently, the electric field became stronger and activate the negatively charged fibers to repel negative charged viruses. This can be achieved by increasing the intensity of the electric field around the fibers of the facemask to discard viruses and prevent their passing through the fibers. Besides, the electric field can induce dipoles, polarize the neutral particles and increase their attraction to the charged fibers.**

**ESC generated on the outer surface of the layers of PP textile separated by PET fibers of 0.2 mm diameter is shown in Fig. 5. PP layers free of PET fibers generated the lowest values of ESC of -2400 volts. It seems that the presence of PET fibers increased the gap between PP layers and therefore increased ESC. Besides, The PET fibers increased the surface subjected to ESC. It was found that when the layers were separated by PET fibers, ESC increased and consequently the strength of the electric field increased, [26 – 28]. It seems that the surface area activated by ESC increased in condition of the separation of PP layers. As the thickness of PET fibers increased, ESC decreased due to the increased resistance of the PP layers to the air flow. It is believed that the double layer of ESC generated induced electric field inside the gap. When air goes through the polymeric fibers, it generates ESC on the polymeric fibers. Generally ESC showed the highest values at the outer surface and decreased with increasing the distance from the tested layers.**

**The effect of using PET fibers of 0.1 mm diameter as spacer on the values of ESC is shown in Fig. 6, where ESC recorded relatively lower values than that measured for PET of 0.2 mm fiber diameter, Fig. 6. The thick layer of PET separating PP layers generated the lowest values of ESC (-1400 volts). It is aimed to generate relatively higher values of ESC of negative charge from air passing through the PP fibers in front of the facemask to repel Covid-19 viruses away. That can be achieved by increasing the air gap between PP layers, where the volume of ionized air increased and consequently ESC increased.**

**Glass beads of 4.75 mm diameter inserted between PP layers showed drastic drop in ESC, Fig. 7. The arrangement [PP GB PP GB PP] displayed the highest values of ESC (-4700 volts) followed by [GB PP GB PP PP] of (-2520 volts). That behavior may be attributed to the air gap introduced between the three layers of PP. The presence of air gap allowed the air to be ionized, where electric field might be generated. Besides, the surface area of PP layers subjected to be electrified remarkably increased. Therefore, the magnitude of ESC increased leading to the increase of the electric field.**

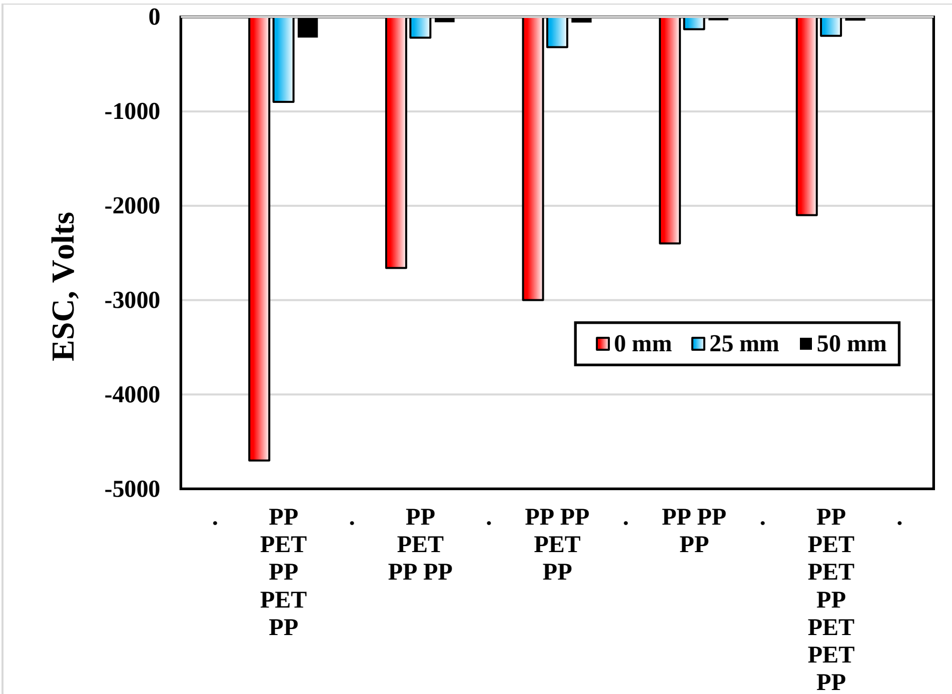



**Fig. 5 ESC generated from PP separated by PET fibers of 0.2 mm diameter.**

**When PC beads of 5.2 mm diameter were inserted as spacer between the PP layers, the magnitude of ESC increased, Fig. 8, where the arrangement [PP PC PP PC PP] displayed the highest values of ESC (-5500 volts) followed by [PC PP PC PP PP]. That observation may be due to the increase of the thickness of the air gap. Further increase in the air gap by introducing relatively bigger PS beads of 8.0 mm diameter recorded relatively lower ESC values, Fig. 9. The arrangement of [PP GB PP GB PP] displayed the highest values of ESC (-4700 volts) followed by [GB PP GB PP PP] by (-2520 volts), where the highest value did not exceed -3000 volts. Based on that observation, the air gap between the PP layers should be adapted to generate the highest value of ESC.**

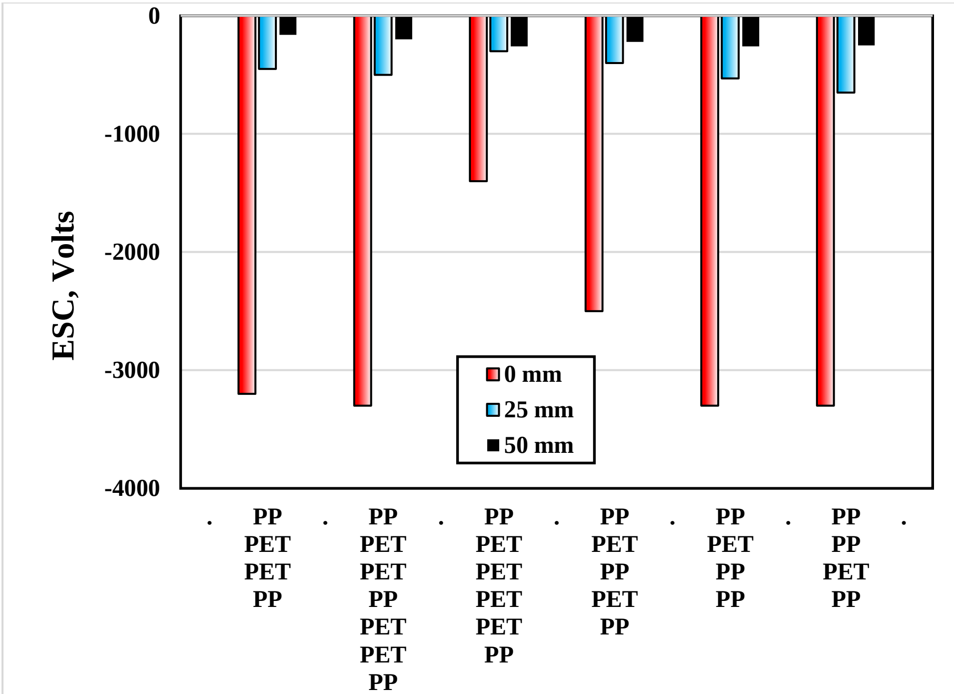



**Fig. 6 ESC generated from PP separated by PET fibers of 0.1 mm diameter.**

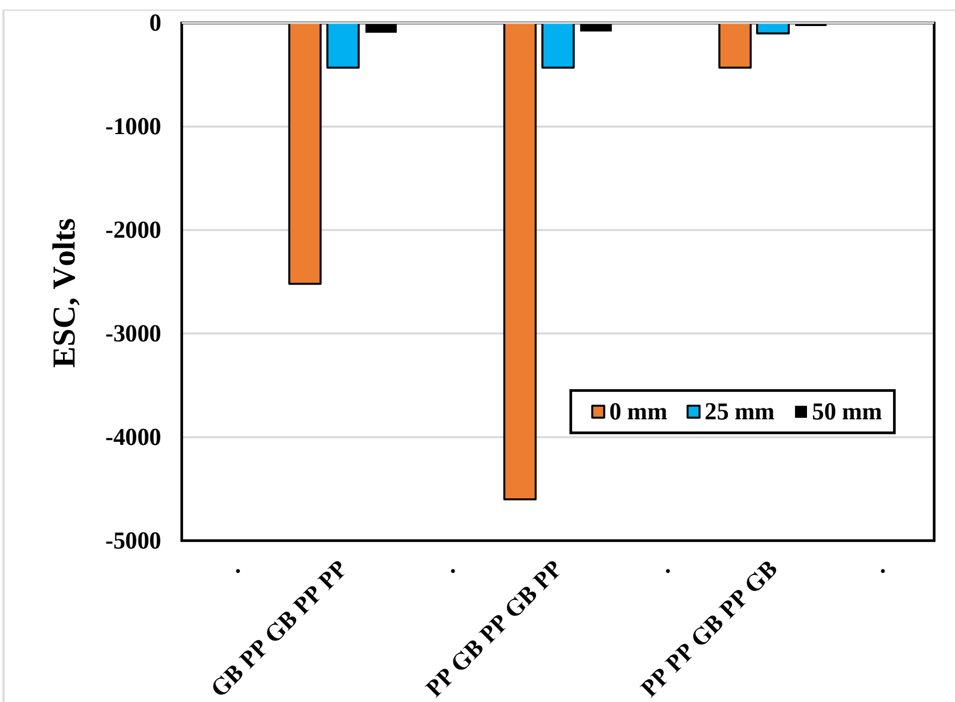



**Fig. 7 ESC generated from PP separated by glass beads (GB) of 4.75 mm diameter.**

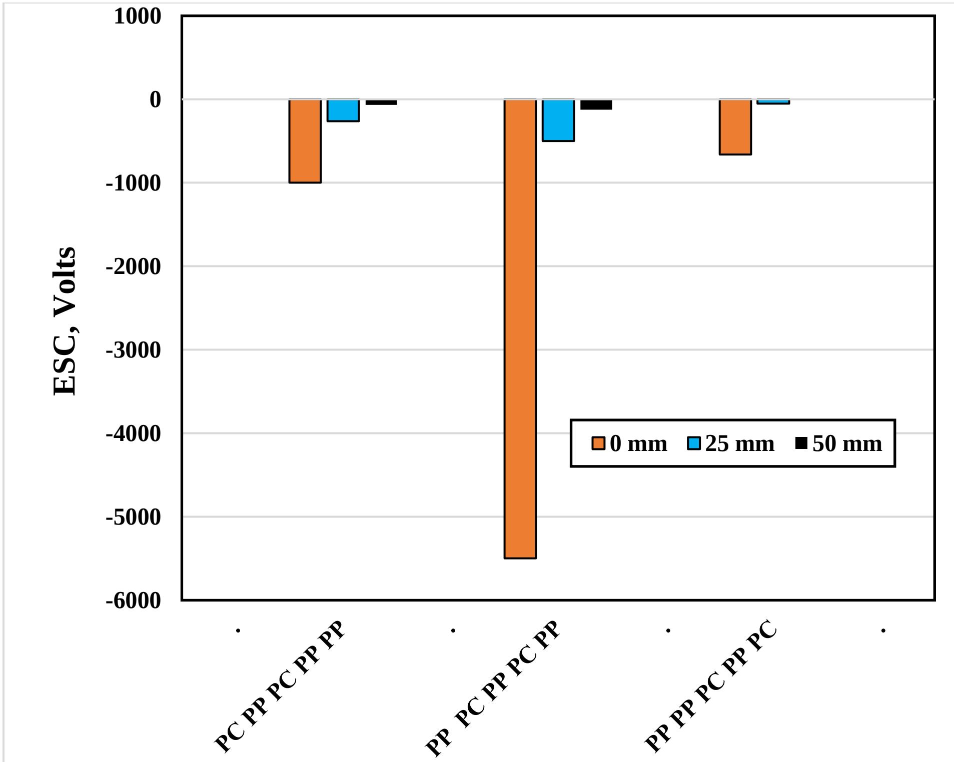



**Fig. 8 ESC generated from PP separated by PC beads (PC) of 5.2 mm diameter.**

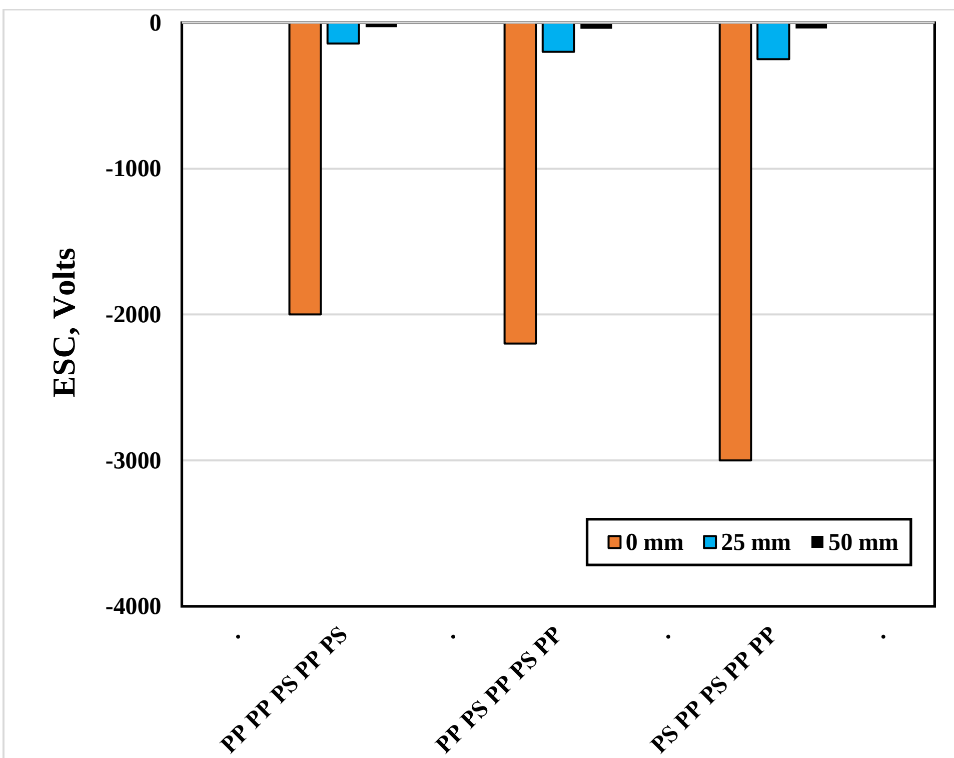



**Fig. 9 ESC generated from PP separated by PS beads fibers of 8.0 mm diameter.**

**The observations of the present experiments showed that inserting fibers or beads of polymeric materials separated the PP layers and increased the air gap between them. When the air passes through the PP fibers they get negatively charged, where the magnitude of ESC increases as the triboelectried area increases. When the magnitude of ESC increases, the electric field increases and, where its ability to repel negative charged viruses increases and prevent them from going back during inhalation.**

## CONCLUSIONS

**1. ESC generated on the outer layer of PP textile separated by PET fibers of 0.2 mm diameter showed an increased values of ESC, where PP layers free of PET fibers displayed the relatively lower ESC values. PET fibers of 0.1 mm diameter showed relatively lower values of ESC.**
**2. Increasing the thickness of PET fibers caused drastic ESC decrease as result of the increased resistance of the PP layers to the air flow.**
**3. ESC generated on the outer surface of PP layers showed the highest values.**
**4. Inserting glass, PC, and PS beads as spacers between PP layers increased ESC.**
**5. The air gap between the PP layers should be adapted to generate the highest value of ESC.**

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