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Study on Inhaler Spacer Using ESD-Safe Material

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Abstract: The aim of this thesis is to perform study on the ESD-safe 3D printing material that can be used for inhaler spacers when compared with other available 3D printing material that are available commercially. The study on ESD-safe characteristics of 3D printing material have been done in the form of study of electrical properties and triboelectric quantification, but the material that were covered by previous study is limited. Most studies done before also focuses more on the application of the material in electrical and mechanical engineering and not on medical application such as for the usage for the fabrication of inhaler spacers. This study will focus more on how accumulation of charge differs between different 3D printing material, which is PLA and ABS material, as well as the fabrication method used in the terms of infill patterns and infill densities. Experimentation done shows that the accumulation of charge only differs with the material, with the infill patterns and densities having little to no effect on the findings. The finding shows that after triboelectric charging, ABS material accumulates no electrostatic charge while PLA material still accumulate a small amount of it indicating that the ABS material is the best material to be used for the fabrication of the inhaler spacer. This shows that when the electrostatic discharge characteristic of a product is being considered, the selection of material is more important when fabricating it using 3D printing, especially for medical purposes.

Keywords: Inhaler Spacer, 3D Printing, ESD-Safe, Triboelectric

1. Introduction

Patient who are suffering from asthma can be treated using inhaled corticosteroids that are delivered using metered dose inhalers (MDI) straight into the patient's lung [1]. While most patient will be able to use the MDIs on their own, some patients such as young children and patient who have problems in performing the correct technique in using the MDIs may require the use of inhaler spacer [2]. Inhaler spacers are commonly made out of conventional plastic [3] which make them very accessible in the market, but quite hard to procure immediately. With the advancement of 3D printing, quick fabrication of an inhaler spacer using a 3D printer is a possibility.

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3D printing involves the fabrication of a material from its 3D drawing form into a product, usually involving gradual addition of material to build the desired model [4]. Many advancements have been made in the 3D printing technology since the 1980s, when the idea of performing rapid prototyping was first conceptualize [5]. Currently, 3D printers are very easily accessible making rapid prototyping a cheaper endeavor to go through. Hence, the possibility arises to use a 3D printer to manufacture inhaler spacers, using available 3D printing material that are currently available on the market.

Fabricating an inhaler spacer using 3D printing method will be very advantageous as it will make this product more easily obtainable, especially during emergency where the inhaler spacer is needed urgently but is not available on hand. However, concern arises regarding the material used for the inhaler spacer, as when using material that are not ESD-safe, the electrostatic charging may cause accumulation of medicinal doses meant for the patient, and unwanted particles on the inside surface of the inhaler spacer. Hence it is very important that the material is carefully selected before fabrication of an inhaler spacer.

In this study, a type of ESD-safe material will be chosen based on the similarities of the materials with the one used in commercially available inhaler spacers. The study will also focus on the most suitable infill pattern and density that can be used for the fabrication of the inhaler spacers. Using the selected material and infill settings, test specimens will be made which will be used for the experimentation.

2. Materials and Methods

The experimentation conducted for this study is the triboelectric charging experiment. Triboelectric charging refers to the transfer of electrons that occur with friction that happens between two material.

2.1 Materials

The test specimen used for the study is made of ABS and PLA 3D printing material that are fabricated using a 3D printer into specimens with a 70 x 10 x 3.5 mm in dimension. A total of nine specimen will be made for both ABS and PLA material, made with the configuration showed in the following table.

Table 2-1: Samples used for testing.

Sample	Infill pattern	Infill density (%)
1	Grid	25
2		50
3		75
4	Tri-hexagonal	25
5		50
6		75
7	Concentric	25
8		50
9		75

Other than the ABS and PLA specimens, a controlled plastic material will also be tested using the same experimentation. This material is a Polypropylene rod that are made into the same dimension with the ABS and PLA specimens.

2.2 Methods

The triboelectric charging experiment performed in this study involve the rubbing of 2 material together to create friction. In this experiment, one of the materials is the test specimens and the

controlled plastic material, and the other material is a wool fabric. The two material will be rubbed together for 40 seconds to ensure that the test specimens is electrostatically charge.

The charged test specimen is then placed over plastic pieces that are obtained by cutting a plastic sheet into pieces approximately 5 x 5 mm in dimension. Since the test specimens has been electrostatically charged, attraction may occur between the plastic pieces and the test specimen. The number of plastic pieces attracted toward the test specimen is recorded. Three attempts will be made for this step for each specimen.

3. Results and Discussion

The results and discussion section presents data and analysis of the study. This section can be organized based on the stated objectives, the chronological timeline, different case groupings, different experimental configurations, or any logical order as deemed appropriate.

3.1 Results

Figure 1: Attraction of plastic pieces observed on each specimen; Polypropylene rod (left), ABS specimen (centre) and PLA specimen (right)

During the experiment it can be observed that the average amount of attraction of plastic pieces differs with the material. The average of pieces attracted by the polypropylene rod is the most, with an average of 3.33 pieces. This is followed with the PLA specimens with its average attracting between 0.67 to 1 plastic piece. The ABS specimens do not show any attraction toward the plastic pieces. A more detailed result can be found in the appendix of this paper.

3.2 Discussions

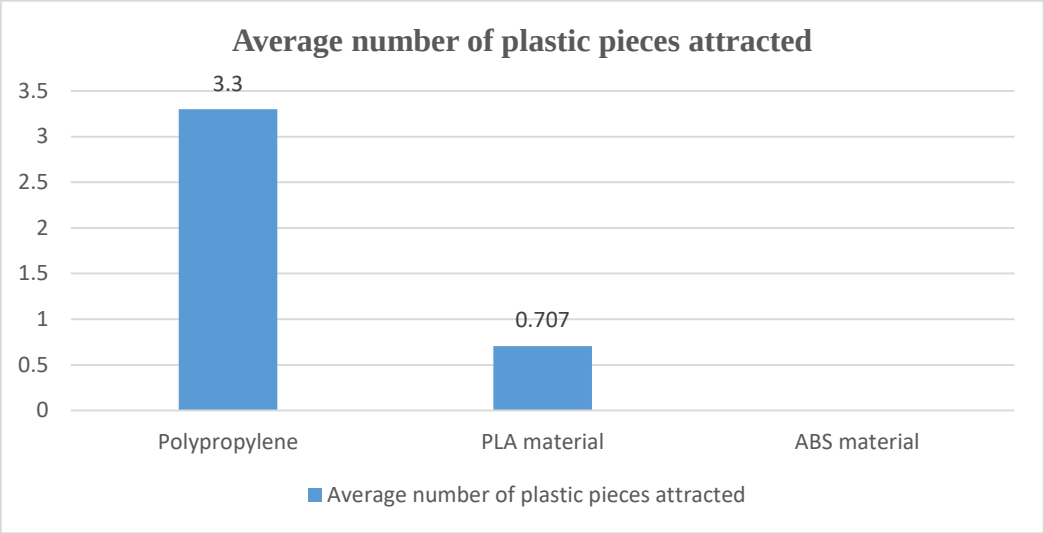

Figure 2: The average plastic pieces attracted by each material, regardless of infill density and infill patterns.

The observe results shows the strongest attraction happened on the polypropylene rod, followed by the PLA specimens and the ABS specimens. While the PLA specimens still shows some attraction towards the plastic pieces, the ABS specimens show no attraction toward the plastic pieces. This means that the ABS material is an ESD-safe material that can be used for the fabrication of the inhaler spacer.

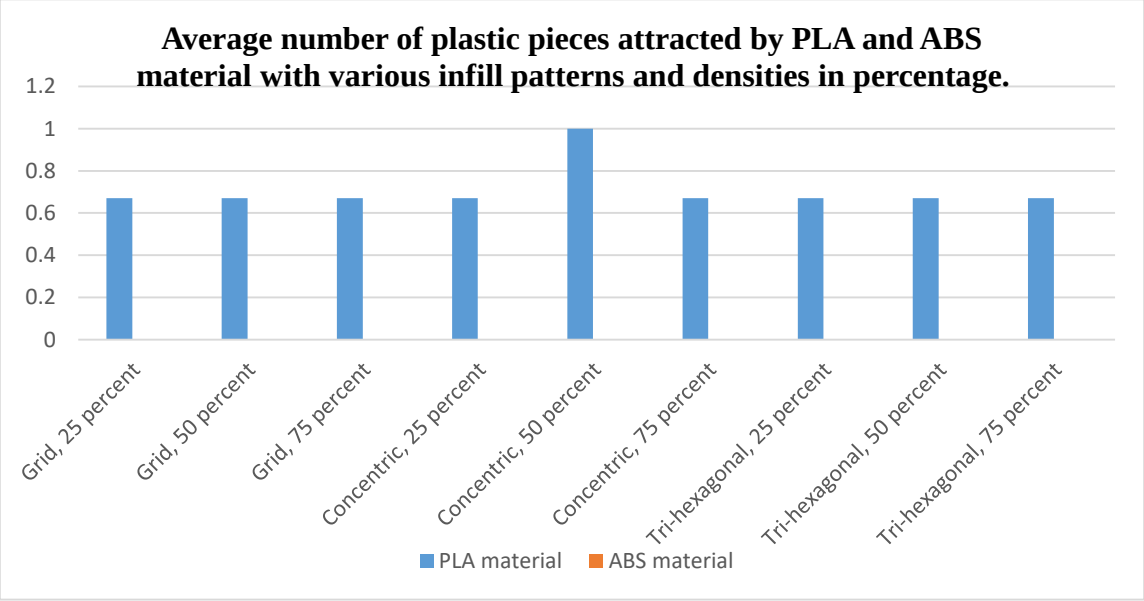

Figure 3: The average number of plastic pieces attracted for PLA and ABS material.

The observed results also shown that there is no relation between the infill patterns and densities and the electrostatic attraction between the specimen and the plastic pieces, as seen from the bar chart in figure 3. This means that the infill configuration has no effect on the fabricated product's tendency to gain electron. That characteristics is mainly affected by the material used themselves based on the observation made from figure 2.

4. Conclusion

The findings of this study shows that the material with an ESD-safe characteristics is the ABS material, as even after the triboelectric charging experimentation method, it shows no sign of accumulating charge, while the PLA material still shows some signs of accumulated charge, albeit less than the polypropylene rod. The study also shows that the infill configuration used during the 3D printing process have little to no effect towards the material's electrostatic properties. Hence, it can be concluded that the best material that can be used for the fabrication of an inhaler spacer will be the ABS material.

Recommendation can be made to perform further study regarding the material used as the experimentation used in this study may not be very precise. Further studies can also be done on other plastic based 3D printing material so that further knowledge can be expand in the 3D printing field.

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