# New Filaments from Used Face Masks as PLA Filament Alternative For 3D Printing: Part I

Changhyun (Lyon) Nam, Hoyong Chung, and Jessica L. Ridgway

Florida State University, USA

## Introduction/Impact of Research Goals

Approximately eight million metric tons of plastic waste are annually dumped into landfill and oceans worldwide (Ford, 2020). This plastic waste comes from a variety of applications (e.g., household items, packaging, living hinges) which spans consumer products to industrial outputs and textile manufacturers. Plastic waste not only causes environmental issues, such as pollution of oceans, rivers, and mountains but also seriously contaminates the entire ecosystem. For several decades, plastic packaging and products have been a major contributor to these environmental issues due to their use in packaging for consumer products. Due to the COVID-19 pandemic, a new product that poses a significant environmental threat has emerged the disposable face mask. It is rare to walk around any city and not observe face masks littering the streets. Face masks were essential and were required, to help stop the spread of the virus. During the COVID-19 pandemic, therefore, 129 billion face masks have been consumed globally generating an enormous amount of waste (Trafton, 2021). As a result of the pandemic, there has been an estimated 7,200 metric tons of medical waste generated which includes single-use disposable face masks (Ford, 2020; Trafton, 2021).

Importantly, the complete decomposition of the discarded plastic-based face masks requires as long as 450 years (Trafton, 2021). Moreover, the natural decomposition process includes the formation of microplastics which are micro/nanometer-size small plastic pieces. These microplastics have direct impacts on animals and human health (Ford, 2020). Therefore, the goal of our research is to create an innovative way to recycle and repurpose disposable face masks. We have conducted an exploratory study that examines the feasibility of melting down face masks made from polymers to create a filament that could be 3D printed to recreate a variety of products. We hope to reduce environmental waste and be able to repurpose the masks into products to be utilized in the health industry, bringing the life cycle of masks full circle.

## Literature Review

Most disposable masks are made from polymers such as polypropylene (PP), polyurethane, and polyester (Potluri & Needham, 2005). A typical PP-based face mask consists of three layers - outer (i.e., barrier), middle (i.e., filler), and inner (i.e., comfort) - as shown in Figure 1. PP is a thermoplastic polymer that is synthesized from a propylene monomer in the presence of an organometallic catalyst. The main source of the propylene monomer is a hydrocarbon that originates from fossil fuel, petroleum (Konda et al. 2020; Shubhra et al., 2013). Moreover, PP has a melting point within the range of 160 – 168°C and has a low density which leads to a lightweight polymer (Habib, 2021). PP can be used to make





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a variety of plastic products including plastic cups. In a comparison of polylactic acid (PLA) and other commodity plastics, Creighton (2018) demonstrated that a cup made of PP had superior qualities to one made out of PLA with PP having a higher threshold for heat and chemical exposure. With this in mind, we conducted laboratory analysis to compare PP to PLA and determine the feasibility of turning PP into a filament to be used similarly to PLA in a 3D printing process.

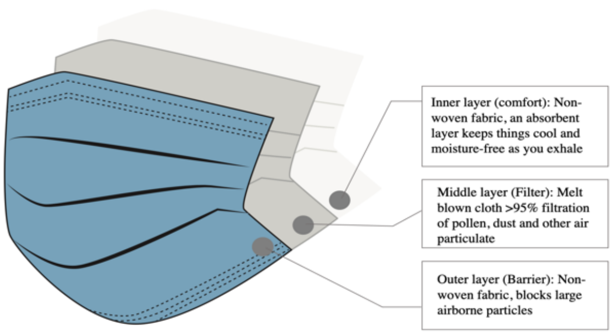


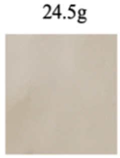
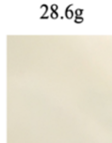
*Figure1*. Three layers structure of single-used face mask.

Based on the literature review, we proposed the following research questions (RQs): *RQ1.* Can single-use disposable masks made of PP be melted down to create a filament for 3D printing? *RQ2.* Can all three layers of the mask be melted down together or do they need to be treated separately? *RQ3.* Would a filament made from melted-down masks have similar properties to PLA which is currently used for 3D printing?

**Method**

The materials obtained for this laboratory testing were a total of 75 commercial, single-use face masks made by FLTR, Inc. We first needed to find the optimal melting temperature to determine a comparison to that of PLA. To do this, the face masks were deconstructed to separate all of the layers, each layer material was cut into 1.5 cm × 5 cm strips. This was done to have samples that would fit into 20 ml vials which were placed in a SHEL LAB oven (Sheldon Manufacturing, Inc.). Three strips of each layer were placed in a vial at a time. We placed three strips so that the quantity of material would be comparable across samples due to the combined sample containing all three layers of the mask. To get an average melting temperature and standard deviation, samples were examined at three different time points.

Table 1. Optimal Temperature, Colors, and Weight for Each Layer and Combined Layers

| Layer | Outer layer | Middle layer | Inner layer | Combined layer |
|---|---|---|---|---|
| Range of MT (°C) | 156°C – 164°C | 172°C – 180°C | 176°C – 184°C | 166°C – 172°C |
| Weight (g) | 29.9g | 24.5g | 28.6g | 35.9g |
| Material color |  |  |  |  |

*Note.* Melting Temperature (MT); Celsius (C)

The process of material testing consisted of gathering three key pieces of information: (1) optimal melting points for each layer, (2) identifying the weight in grams of 30 pieces (16 cm × 15 cm) melted down by each layer, and the combined three layers of face mask, and (3) the outcome color based on material types. The optimal melt temperature, weight of each sample, and material color are shown in Table 1.

**Results/Implications**

The results showed each sample melted within a range of 156 °C to 184 °C, including a melted temperature range (166 °C to 172 °C) of the combined layers sample. Since this temperature remains low and within the range for 3D printing, it is feasible to assume that an entire mask (excluding the ear elastic straps and a nose bridge strip) could be melted down to make an effective alternative plastic. It should be noted that the combined layers also included the threads from the masks which resulted in a heavier weight but is still within an acceptable weight range for 3D printing. Not surprisingly, the color of the plastics reflected that of the layer. The combined sample merged the colors of all the layers having an overall blue look with a marbling of tan. Therefore, we are excited to report that our testing revealed that the entire mask can be melted down to create filaments. This result has implications for making the process more environmentally friendly and less labor-intensive as the masks do not need to be separated by layer. Our results show that melted-down masks have similar and perhaps superior properties to PLA, including melting at a lower temperature.

**Conclusions/Future Research**

This initial exploratory testing is stage 1 in a larger research project. We are currently attempting to validate the melted-down masks as material to be used in a 3D printer by using ProtoCyler Plus (ReDeTec™), a filament extruder, to produce filaments made from the melted-down masks. Future research will explore a comparison between melted-down masks and PLA more deeply. With continued exploration and validation, our research team hopes to produce a collection of 3D-printed objects which can be used within the health industry. Additionally, we aim to be able to use our knowledge gained from this exploration to further explore additional plastic waste products which might also be able to be used as filaments for 3D printing.

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