Recycling Disposable Cups into Pipette Tips

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Abstract: The overwhelming problem of plastic waste management demands innovative approaches to recycling plastic wastes. One of the most abundant plastic wastes but very challenging to recycle are paper cups lined with a thin polyethylene film, also known as paper plastic laminates (PPL). In this paper, we present the creation of pipette tips from disposed coffee cups as an inventive way of recycling PPL. The fabricated PPL pipette tips exhibit comparable accuracy in drawing and dispensing liquids compared with the standard polypropylene pipette tips. The created PPL pipette tips are ideal to be used in lower-level educational experiments where research-grade consumables are not a crucial requirement. The presented proof-of-concept has promising potential in aiding the waste management of disposable paper cups and pipette tips, thus making laboratory science education more sustainable.

Key Words: Paper plastic laminates; single-use items; laboratory plastic wastes; plastic pollution; environmentally sustainable research

1. INTRODUCTION

Plastic pollution is a significant threat to the planet and its inhabitants; wherein single-use plastics are one of the main contributors to plastic pollution (Giacovelli, 2018). Plastic pollution is driven by the increasing demand for plastics in diverse applications such as food, transportation, and sanitation (Thompson, 2017).

Plastic recycling is one of the ways in which plastic pollution can be managed, and it can be ranked into four categories. The first and the best way to recycle plastics is plastic depolymerization to form the constituent monomers to produce new plastic products. The second is by conversion into lower-grade plastic products. The third is by incineration, and if the first two options are not feasible, the fourth and the last resort is by disposing them into landfills (Sidkar, 2020). Disposable cups, such as those made from paper plastic laminates (PPL), are among the single-use plastics that are challenging to recycle due to the thin plastic film coating the cellulose material that needs to be separated. Since it is made from paper, it is perceived as environmentally friendly and recyclable that it may be included along with biodegradable wastes, but a majority of them are actually not. Aside from their accumulation in the environment, the global warming potential of disposable cups made of PPL is another important environmental issue (Håkkinen and Vares, 2010).

In an effort to promote plastic recycling, especially for this type of waste, we present a method of creating laboratory pipette tips out of used PPLs. Recycling PPL cups can decrease the adverse effects of plastic accumulation in the environment and reduce PPL cups' environmental footprint by 40% (Foteinis,

2020). This proof-of-concept not only presents an innovative method of recycling disposable cups made of PPLs but also promotes sustainability in research and teaching laboratories, which also consume substantial plastics-based products (Banks et al., 2020).

2. METHODOLOGY

In order to create these PPL pipette tips, the main materials needed are a cleaned, used plastic-lined coffee cup and a quick-dry adhesive or an adhesive tape.

The used PPL cups were first cleansed and disinfected with a hypochlorite solution and left to dry at room temperature. The template for the PPL pipette tips is shown in Fig. 1, while the steps in rolling the cut sheet into PPL pipette tips are illustrated in Fig. 2.

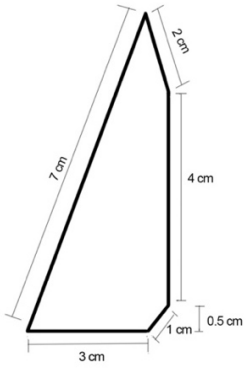

Fig. 1. PPL pipette tip template with dimensions.

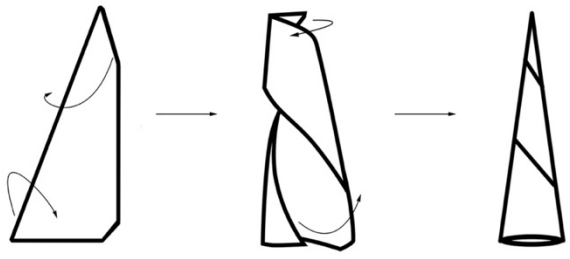

Fig. 2. Diagram for rolling the PPL pipette tip.

For the first step, the upper-right edge of the template must be rolled inwards to the left and upwards. The bottom apex must be rolled inwards to the right and then upwards. These must be done simultaneously to achieve the form in the second step. From this, the same edges from the first step must be twisted further to form a cone and finally applying the adhesive. Figs. 3a and 3b present the actual steps for creating these tips, with Fig. 3c shows the finished material, with a quick dry adhesive was used to seal the edges.

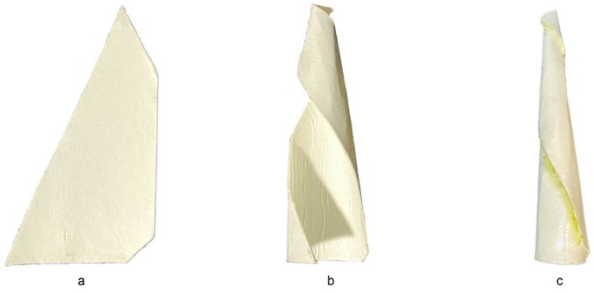

Fig. 3. Actual PPL pipette tip images.

3. RESULTS AND DISCUSSION

To verify if these PPL pipette tips can deliver volumes comparable to a standard 1 mL capacity polypropylene pipette tip, three PPL pipette tips were prepared and were compared against three randomly selected 1 mL capacity polypropylene pipette tips. A single BioPette™ (Labnet International Inc, U.S.A.) pipette was used throughout the experiment and was set to deliver a volume of 1 mL.

Each pipette tip was used to obtain 1 mL of distilled water. The contents of the tip were then dispensed in a tared beaker on a laboratory balance, and its weight in grams was recorded. This was done for ten replicates for each tip. Since the density of distilled water at standard temperature and pressure conditions is 1 g/mL, the mass of the dispensed liquid should be close to 1 g. As Table 1 shows, the PPL pipette tips have a statistically similar performance with the standard polypropylene pipette tips, based on ANOVA.

Table 1. Performance comparison of the fabricated PPL pipette tip and the standard polypropylene tip (mean ± standard deviation). For each type of tip, three tips were used ten times (n=30 for each type of pipette tip).

Standard Polypropylene Pipette Tip	PPL Pipette Tip
1.18 ± 0.01 g*	1.07 ± 0.08 g*

*p-value < 0.001

Moreover, the PPL pipette tips demonstrate reliable structural integrity since their performance remains consistent despite being used for ten times (Table 2).

Table 2. Performance of ppl pipette tips when used ten consecutive times in drawing and dispensing distilled water (n= 10 for each tip).

PPL Pipette Tips	Mass (g) of 1 mL of Distilled Water Dispensed (mean ± standard deviation)
PPL Tip 1	1.07 ± 0.08 *
PPL Tip 2	1.04 ± 0.06 *
PPL Tip 3	1.05 ±0.05 *

*p-value < 0.05

4. CONCLUSIONS

The performance of the PPL pipette tips is statistically comparable to the standard polypropylene pipette tips. This makes the PPL pipette tips a viable alternative that would help lessen the pollution from single-use items. The created PPL pipette tips have promising potential to be used in lower-level science experiments that do not require research-grade laboratory consumables. As an example, these PPL pipette tips are ideal in introductory skill-building activity on how to properly use a pipette wherein food-colored water is used as the specimen.

The presented proof-of-concept that recycles paper cups into useful and accurate pipette tips is a promising addition to existing technologies that likewise aim to manage this seemingly dead-end plastic product. Some of these existing green technologies include the utilization of PPLs as reinforcing agents for propylene to create a novel composite material (Mitchell et al., 2014), using waste paper cups as adsorbent material for wastewater treatment (Shukla et al., 2020), extracting cellulose nanocrystals from disposed PPL cups (Nagarajan et al., 2020) and the development of an efficient catalytic pyrolysis method for the controlled degradation of the waste paper cup (Shin et al., 2018).

5. REFERENCES

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