Inexpensive, Open Source Micropipettes

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Abstract

Micropipettes are essential instruments in almost any biology lab, especially since micropipetting is a necessary technique in many types of experiments. However, commercial micropipettes are often expensive, and these costs can pose a barrier for many teaching labs. In an attempt to make micropipettes more affordable and thus more accessible to others, we provide open source designs for building hand-held micropipettes using common lab supplies (e.g., plastic syringes and glass or Pyrex pipettes that are cut to size) at a cost of about $2 to $5 per device. When tested, these micropipettes performed comparably to commercial models both in terms of accuracy and precision. Similar to other open source scientific tools that we have developed, we have named these micropipettes "OPN Micropipettes," and we hope that others will be able to use and modify them to fit their educational or other needs.

Introduction

Micropipetting is a basic technique used in many biological fields, and being able to transfer microliter amounts of liquid quickly and correctly is necessary in many different types of experiments. Not only are micropipettes essential in a professional lab settings, they are also extremely useful in many teaching labs. For example, in a cell or microbiology lab, students must frequently transfer precise volumes of cells, nutrients, or other substances to conduct their experiments. Generally, students use commercial micropipettes to meet these needs, which typically come in 20-, 200-, and 2,000-µL models.

Unfortunately, most commercial micropipettes are expensive, costing between $130 and $200 each. For example, at August 2016 prices, Gilson pipetman cost around $130 each for their P-series models, and the CAPP Bravo pipette series cost about $190 each for sizes ranging between 10 to 1,000 µl. As a result, supplying a teaching lab with 10 such sets would cost between $3,900 and $5,700. Not surprisingly, these high costs are often problematic for many schools, particularly those that lack the resources for such expensive equipment.

While there are some low-cost alternatives to commercial pipettes, such as glass pipettes connected to a pipette pump or filler bulb, these devises can be difficult to control, especially when transferring small volumes of liquid. Plus, filler bulbs and pipette pumps commonly cost between $5 and $25 each (and, thus, around $50 to $250 for a set of 10, not including the cost of the glass pipettes). There are also fixed-volume pipettes that can be purchased for about $20 to $25 each (or around $200 to $250 for a set of 10). However, these instruments can only measure a specific amount of liquid, and biology experiments frequently require the transfer of multiple different volumes.

Alternatively, instructors could try making their own micropipettes, and a number of interesting and creative micropipette designs have been proposed in the literature. These models include putting a 1-mL bulb on the end of a Pasteur pipette that is connected to a serological pipette through rubber tubing (Swanson, 1994) or attaching a liquid soap dispenser to a small hose (Grassmick, 1969). Another design uses a syringe to move liquid through a series of drawn glass and rubber tubes that then connect to a glass pipette (Lapworth, 1982).

Some of these designs, however, may be too complicated for students to make or use and, thus, may not be optimal in an educational or experimental setting.

In an attempt to offer an alternate design for making low-cost micropipettes, we describe how to build a set of simple yet accurate micropipettes using common lab supplies, such as plastic syringes, Pyrex or glass pipettes, a standard plastic straw (roughly 7-mm in diameter), and disposable micropipette tips (Figure 1). These items can be purchased online from websites such as Amazon (syringes and pipette tips), Carolina Biological (pipettes), or Grainger (for the 0.1-mL pipettes), at local stores (plastic straws), or from other commercial vendors. Using these materials, we have developed 5,000-, 2,000-, 200-, and 20-µL models, and like other inexpensive scientific devices that we have developed (Stewart and Giannini, 2016), the designs and materials needed to make these micropipettes are all open source. As such, we have named them "OPN Micropipettes."

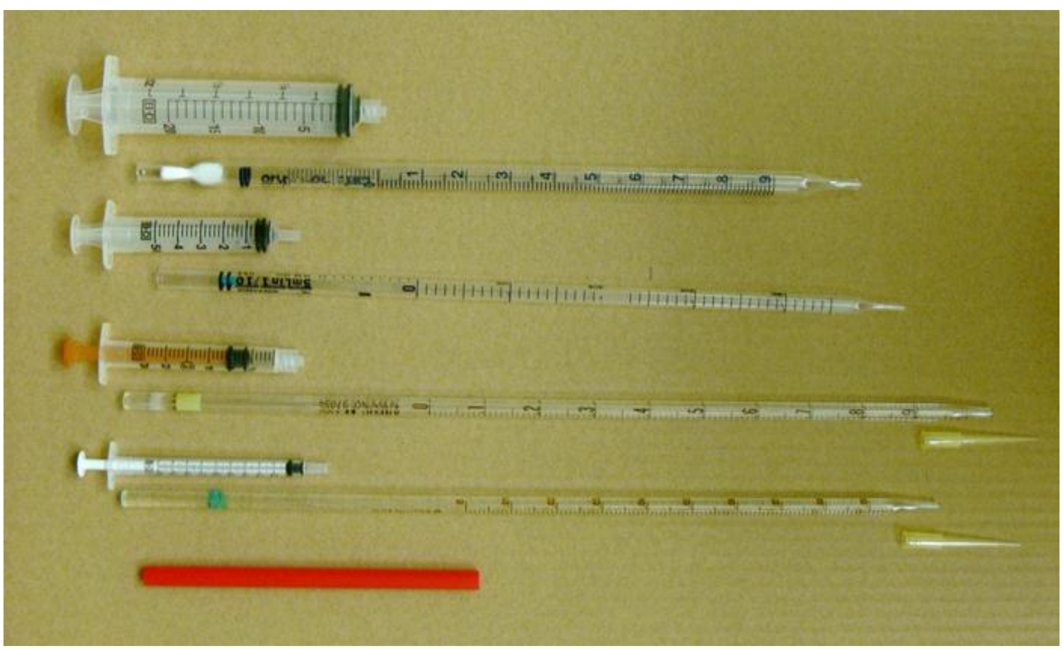

Figure 1. From top to bottom, the materials needed for the 5,000-, 2,000-, 200-, and 20-µL models of the OPN Micropipette.

Materials and Methods

In addition to the plastic syringes, corresponding Pyrex or glass pipettes, and disposable micropipette tips mentioned above (Figure 1; Table 1), readers will further need the following tools and supplies to make a set of OPN Micropipettes: a scissors, hobby knife, or single-edged razor blade to cut the plastic syringes ($2 to $5); a triangular hand file ($5 to $10) to cut the glass pipettes; as well as electrical tape ($1 to $5) and quick-drying epoxy ($3 to $15) to provide an airtight seal between the pipette and syringe. We use epoxy because many brands are non-toxic once they dry, and should not contaminate samples unlike other adhesives (such as super glue).

Table 1. The basic materials used to make OPN Micropipettes and approximate costs at August 2016 prices, not including taxes or shipping.

Model	Materials	Total Cost ($)	Cost per unit ($)
5,000-µL	Pyrex 10 mL pipette (20 count)	13.65	0.68
	Becton Dickinson 20-mL syringe (40 count)	16.00	0.40
2,000-µL	Pyrex 5 mL pipette (30 count)	18.45	0.62
	Becton Dickinson 5-mL syringe (100 count)	18.55	0.19
200-µL	Pyrex 1 mL pipette (50 count)	18.20	0.36
	Becton Dickinson 3-mL syringe (100 count)	17.50	0.18
20-µL	Granger 0.1 mL pipette (12 count)	41.65	3.47
	Becton Dickinson 1-mL syringe (100 count)	15.00	0.15
	Straw (50 count)	5.00	0.10
	Micropipette tip (1,000 count)	10.00	0.01

To make an OPN Micropipette, cut the Pyrex or glass pipette to the the desired length (Figure 2), using a hand file to make a small nick in the glass about 1 or 1.5 inches above the intended maximum capacity for the pipette. Then, break the glass on the nick. Next, take the syringe that corresponds to the pipette (Table 1) and cut off the end near the tip using a scissors, hobby knife, or a single-edged razor blade (Figure 2A). To make the 5,000-, 2,000-, and

200-µL micropipettes, wrap electrical tape around the top of the glass pipette until it fits tightly into the open end of the syringe (Figure 2B). Then, use expoxy to secure all of the pieces together (Figure 2B) and let the pieces cure overnight for a strong bond. To facilitate this process, we typically tape the OPN Micropipette to the edge of a table or a shelf in the lab, so that the pieces are vertically stacked above each other as the epoxy dries.

To make a 20-µL micropipette, cut the glass pipette and syringe tip as described above. Then, take a 2-cm section from a plastic straw and epoxy both the syringe and pipette into it, while making sure that the hole at the top of the glass pipepette remains open (Figure 2A, bottom). This allows the syringe and pipette to be connetected in an airtight fashon. As an optional step to improve the accuracy of the 20- and 200-µL models, readers can attatch the tip of a disposable micropipette using epoxy (Figure 2A). To do so, cut the “collar” off of a disposable micropipette tip (Figure 2, inset). Then, epoxy the tip of the disposable micropipette to the glass pipette (Figure 2B, bottom) and let the pieces again cure overnight (as described above).

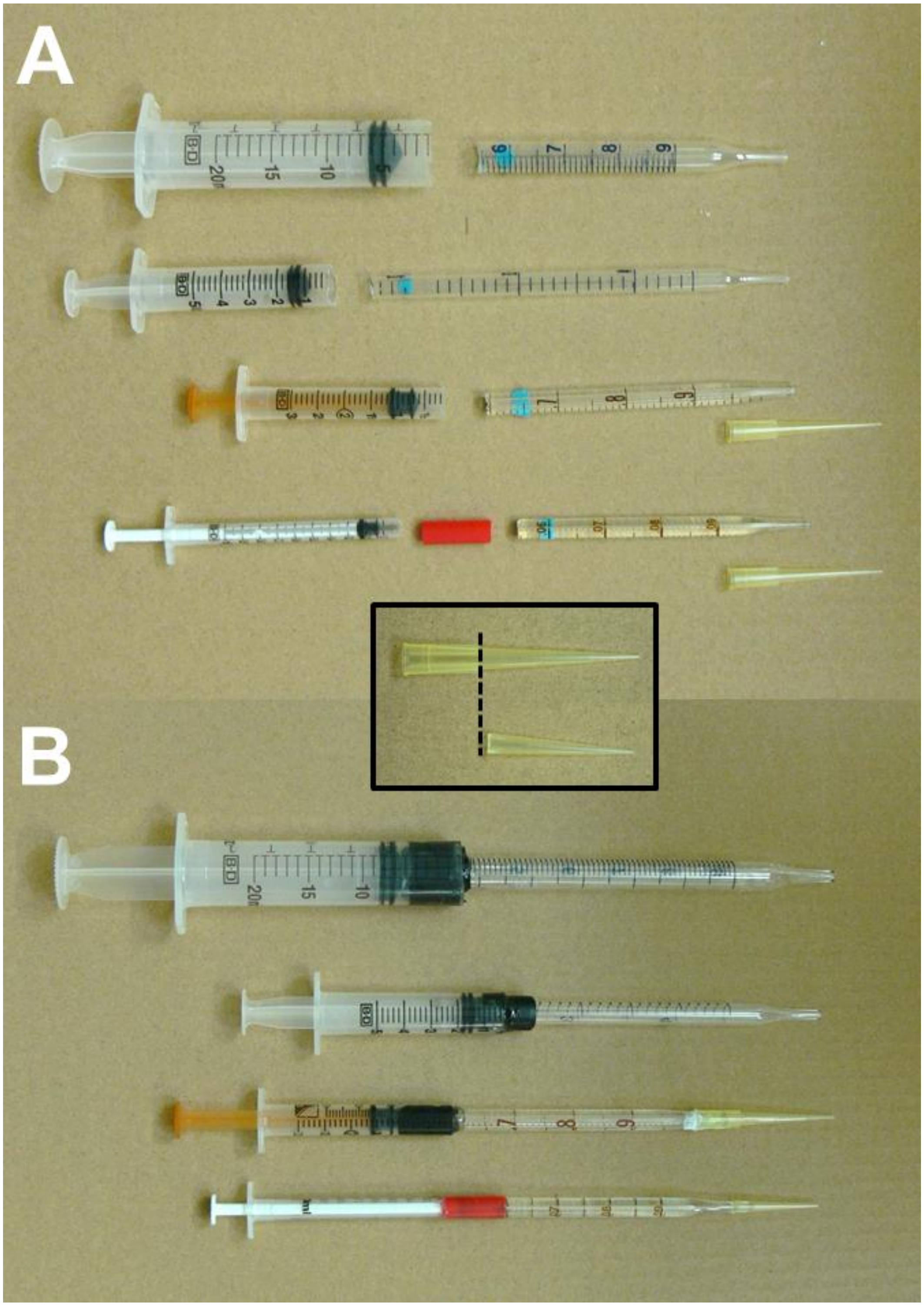

Figure 2. Making the 5,000-, 2,000-, 200-, and 20-µL models (from top to bottom). (A) The initial supplies with the plastic syringes and glass or Pyrex pipettes cut to size. (B) The assembled OPN Micropipettes, which have been taped and epoxied together. The inset shows how to cut a disposable micropipette tip, so that it will fit onto the pipettes for the 200- and 20-µL models.

Calibration and Testing

We tested these versions of the OPN Micropipettes by transfering set volumes of water (10, 100, 1,000, and 5,000 µL) onto a piece of Parafilm placed on a digital analytical balance. This process was repeated 20 times for each volume with the scale tared after each sample was recorded. Then, means and standard deviations were calculated. Each mean was then compared to the "true" theoritical weight of water at each volume to calculate a percent error (Table 2). As a control, this process was repeated using three Gilson pipetmen (the P-20, P-200, and P-2000 models). In addition, ten minutes of practice were allowed with the OPN micropipettes before the trials were conducted.

Hazards

Although the hazards associated with making a set of OPN Micropipettes are relatively minimal, readers should use great care when cutting the plastic syringes and glass or Pyrex pipettes given the sharp tools involved and occasional sharp edges created. Readers should also wear the proper eye protection when cutting these pieces to avoid potential injury. For these reasons, we suggest that instructors cut these pieces themselves, especially if using a hobby knife or single-edges razor blade to cut the end of the syringes.

In addition, readers should know that epoxy consists of a resin and a hardener, both of which can irritate the skin and eyes. These compounds can also cause allergic reactions on contact (e.g., red, itchy, and/or blistered skin), and the related epoxy vapors can cause headaches, nausea, dizziness, respiratory irritation, and other potential harms if inhaled. Obviously, these chemicals should not be swallowed or ingested since they could cause internal irritation or damage as well. Epoxy resin further contains chemicals that can cause cancer, birth defects, and other reproductive harms. Readers should therefore wear the proper protective equipment when working with epoxy (e.g., gloves, glasses or googles, a lab coat or other appropriate clothing, a mask or respirator as necessary). Readers should also work in a well-ventilated area (or under a fume hood) when using epoxy in order to reduce the hazards posed by any related vapors.

Results

The OPN micropipettes performed comparably to the commercial alternatives, generally having slightly larger percent errors and slightly lower standard deviations (Table 2). For example, the OPN Micropipettes had percent errors ranging from -4.30% to +2.63% while the percent error for the control (i.e., Gilson) pipettes ranged from -0.84% to -0.32%. Also, as a percentage of their means, the standard deviations for the OPN Micropipettes ranged from 0.53% to 3.01% compared those for the Gilson models, which ranged from 0.091% to 2.94%. Thus, by either measure, both models performed similarly and within an acceptable range of error (e.g., ± 5%).

Table 2. Results of OPN and Gilson micropipette testing.

Size (µL)	Micropipette	Test Volume (µL)	Mean (µL)	Standard Deviation (µL)	Percent Error
20	OPN	10	10.0365	0.210	0.365%
	Gilson	10	10.0000	0.294	0.000%
200	OPN	100	102.630	0.548	2.63%
	Gilson	100	99.680	0.902	-0.320%
2,000	OPN	1,000	1019.604	23.0	1.96%
	Gilson	1,000	991.610	23.5	-0.839%
5,000	OPN	5,000	4785.114	144	-4.30%

Discussion

Given their simplicity and affordability, we hope that these OPN Micropipettes will be a usefull tool for students in both introductory and advanced teaching labs. For example, their easy-to-assemble design should enable students to build their own set of OPN Micropipettes to use in lab, which might further spark an interest in designing other scientific tools in the future.

Moreover, by our estimate, at August 2016 prices, it would cost about $200 to make 112 micropipettes (20 of the 5,000-, 30 of the 2,000-, 50 of the 200-, and 12 of the 20-µL models), which includes the cost of the tools and other supplies described above. Furthermore, the next 112 micropipettes would cost about $92 to make, given the surplus syringes and pipette tips. At these prices, a school could make over 220 OPN Micropipettes for the price of about 2 or 3 commercial ones.

Of course, unlike commercial models with disposable tips, the OPN Micropipettes should be cleaned after use, and instructors may want to have dedicated OPN Micropipettes for specific substances or chemicals. We also encourage students to practice with their OPN Micropipettes before using them in order to become familiar with their operation (including how to use the calibration marks on the side of the glass or Pyrex pipettes to measure out samples). That being said, we have found that these OPN Micropipettes are easy for students to use, and we hope that these micropipettes will help to broaden the scope of the scientific experiments that students can conduct in an introductory or advanced teaching lab.

Disclosures

The authors declare that they have no conflicts of interest related to any product, brand, company, website, or other item discussed in this article. In fact, we encourage readers to experiment with different materials to improve upon these designs.

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