Automating Processes for Reagent Storage in Microfluidic Chips

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Introduction

Point-of-care diagnostic devices enable rapid disease detection but can require labor-intensive fabrication [1]. This study aimed to automate the lyophilization process for microfluidic chip reagents by designing a 3D-printed rig to transfer frozen reagent pucks [2]. The device was evaluated for performance in terms of speed and reagent preservation, demonstrating reduction in handling time, improved reproducibility, and minimized reagent loss.

Methods

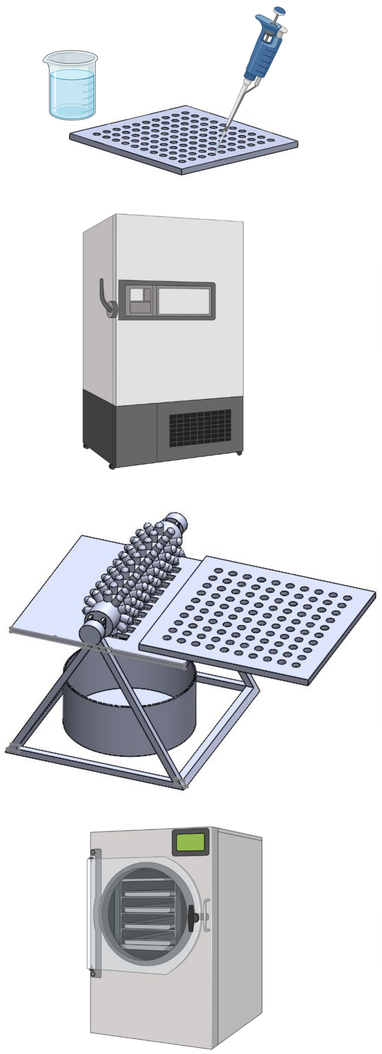

Figure 1. Process flow diagram illustrating the preparation of liquid reagents for lyophilization. Created with *BioRender.com*

Background

	Stability	Shelf Life	Preparation Time	Storage Requirement	Transport Feasibility
Liquid Reagents	Low (cold chain required)	Shorter	Quick to prepare	Refrigeration needed	Challenging without storage
Lyophilized Reagents	High (even at room temp)	Extended	Longer initial preparation	No cold chain necessary	Easy in most settings

Table 1. Comparison of advantages and limitations of Liquid and Lyophilized reagents in diagnostic devices. Lyophilized reagents offer great stability and are better suited for resource-limited settings while liquid reagents are simpler to prepare and use in controlled environments.

Results

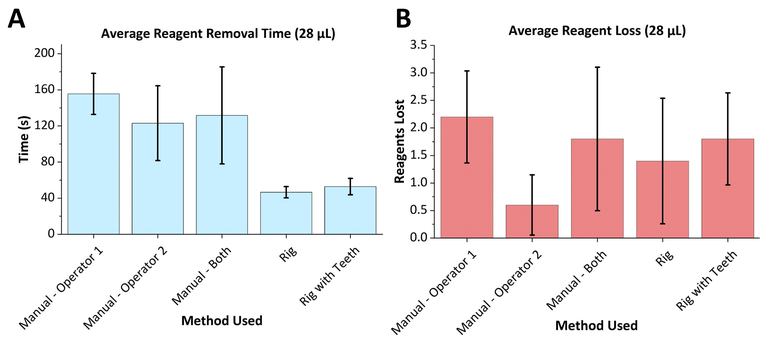

Figure 2. Trials performed with 28 µL of liquid. (A) Average time required to remove frozen reagent shapes using manual and rig-assisted methods. (B) Average number of reagent shapes lost during removal.

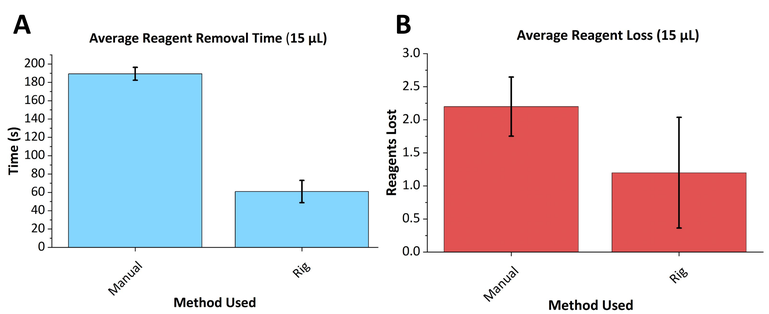

Figure 3. Trials performed with 15 µL of liquid, reflecting a volume more applicable to actual diagnostic use. (A) Rig-assisted removal was significantly faster than manual removal (p<0.001). (B) Average number of reagent shapes lost during removal.

Results

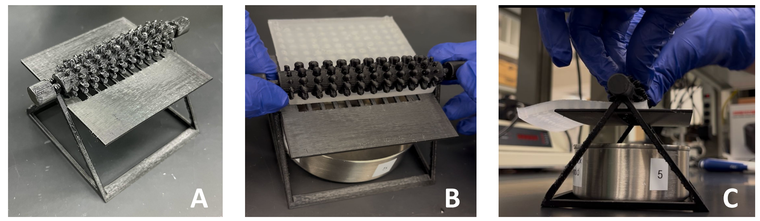

Figure 4. Photographs of the 3D-printed rig prototype. (A) Isometric view of the rig components. (B) Front view of silicone mold being guided through rig. (C) Lateral view of the rig in use, with a silicone mold being processed and reagent shapes ejected into capture pan.

Conclusions & Future Work

- The 3D-printed rig significantly reduced 15 µL reagent removal time compared to manual methods (p<0.001).
- Reagent loss remained consistent between techniques (p=0.087).
- The rig offers an efficient and reliable solution for streamlining the reagent freezing and removal process.
- Refine the mold insertion method to ensure more consistent and replicable use of the rig.
- Utilize multiple supporting components to prevent cross-contamination between different reagents.
- Explore automation of additional steps in the lyophilization process and broader microfluidic chip manufacturing.

References

[1] S. Vashist, "Point-of-Care Diagnostics: Recent Advances and Trends," *Biosensors*, vol. 7, no. 4, p. 62
[2] Nayra Oliveira Prado *et al.*, "Development and evaluation of a lyophilization protocol for colorimetric RT-LAMP diagnostic assay for COVID-19," *Scientific Reports*, vol. 14, no. 1
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