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Abstract

A high-volume extrusion mechanism for printing hydrogels

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In the field of extrusion-based bioprinting, various commercial and open-source systems have been proposed [1]. However, almost all proposed systems rely on the direct extrusion of the material through a nozzle connected to a syringe which is moved across the build platform in the printer. This design limits the printable volume to the volume of the syringe and the mass of the syringe can become a challenge when moving across the build platform. Pusch et al. addressed the trade-off between large volume and precision in extrusion-based bioprinting and proposed their own large volume extruder [2]. Even though this design has a larger volume, it is still limited to the size of the syringe (60 ml), as it is the case for other high volume extrusion systems [3, 4] as well.

In this contribution, we propose a high-volume feeding system for hydrogels, based on two syringe pump extruders working in a complementary manner. While one of the syringe pumps feeds material through a silicone hose to the nozzle, where it is extruded, the other can draw up material from a reservoir of arbitrary volume. When the extruding syringe is fully depleted, the syringe pumps swap their functions. The filled syringe feeds the material to the nozzle, while the depleted can draw up material from the reservoir. This is a cyclic process, pumping the hydrogel from the reservoir to the nozzle. The flow direction is controlled by custom valves. To achieve a sterile process and to avoid clogging of inaccessible or expensive parts, contact of the material to moving parts must be minimal. Thus, the valves are carried out as hose pinching valves and only the piston of the syringe has contact with the material. Since a syringe is usually sterile for initial use and can be easily exchanged after a print job, this is a suitable design.

Besides the proposed high-volume feeding mechanism, the system allows the use of stronger motors to extrude high viscosity materials, as the motors remain immobile. Additionally, the system can be duplicated for different materials and the materials may be mixed at the nozzle of the bioprinter, allowing multi-material bioprinting.

AUTHOR'S STATEMENT

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REFERENCES

[1] Cody O. Crosby, Open-source extrusion 3D bioprinters: Trends and recommendations, Bioprinting, Volume 38, 2024, e00336 https://doi.org/10.1016/j.bprint.2024.e00336.
[2] Kira Pusch, Thomas J. Hinton, Adam W. Feinberg, Large volume syringe pump extruder for desktop 3D printers, HardwareX, Volume 3, 2018, Pages 49-61, https://doi.org/10.1016/j.ohx.2018.02.001
[3] Evren Demircan, Beraat Özçelik, Development of affordable 3D food printer with an exchangeable syringe-pump mechanism, HardwareX, Volume 14, 2023, e00430, https://doi.org/10.1016/j.ohx.2023.e00430.
[4] Cory Darling, Damon A. Smith, Syringe pump extruder and curing system for 3D printing of photopolymers, HardwareX, Volume 9, 2021, e00175, https://doi.org/10.1016/j.ohx.2021.e00175.