Micro-gel Maker

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Introduction

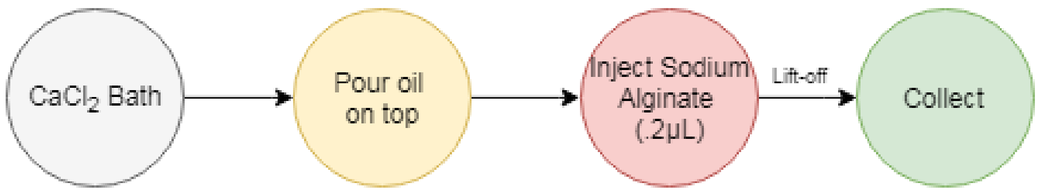
The field of thermosensitive alginate micro-gels finds its use in many pharmaceutical processes such as drug encapsulation or cell growth. This project aims to find a fabrication process through which we can systematically produce size-controlled spherical gels of radius < 1 mm through a mix of sodium alginate and calcium chloride.

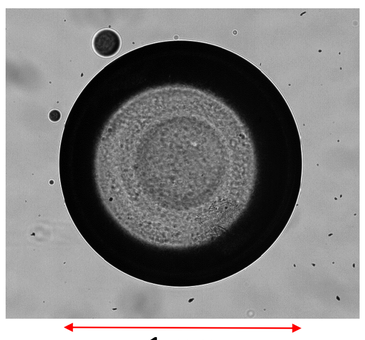
Reactant concentration choice

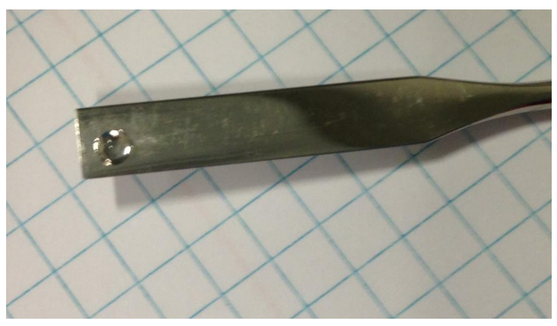
Idea: Find the optimal concentrations for both calcium chloride and sodium alginate in order to find the right viscosity & hardness of the gel. We settled for a calcium chloride concentration of 4% and a sodium alginate concentration of 0.75% following trial-and-error testing.

Syringe experiment

The first tryout consisted in making gels by injecting the alginate directly in the calcium bath. The oil film that stayed on top allowed us to yield (dyed) proper gels. However, the production yielded macro-gels, with a difficult collection process, and is thus not viable for producing size-controlled gels.







Mixer

Protocol:

- Place the magnetic stirrer in the Calcium bath.
- As the solution is being blended, gradually poor the alginate from a syringe.
- Stop the stirrer and collect.

This method yielded large amounts of gel, but of irregular shapes and sizes due to the wild mixing.

Microfluidic device

Principle:

The alginate arriving from the nozzle tip reacts with the calcium as shown, and proceeds into the oil-filled collection tube and onto the collection plate.

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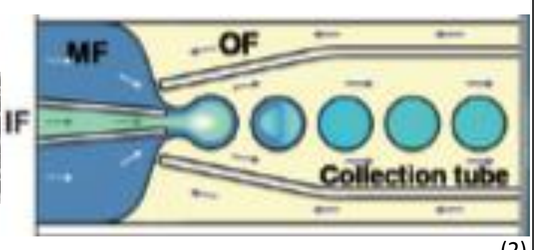

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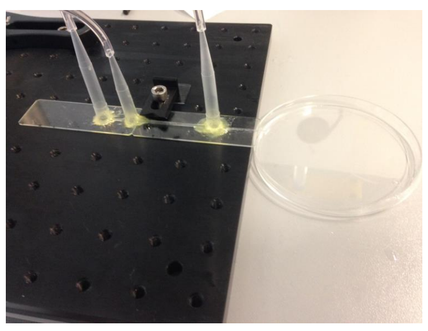
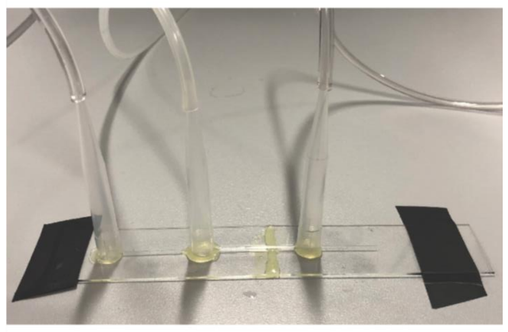
Challenges:

- Nozzle handling: the production process requires extreme precision, and the tip insertion involves placing a 10 µm nozzle tip inside a 70 µm tip collector, that needs to stay static during gluing.
- Interface control between the calcium and oil (push-pull).
- Sealing quality & strength: glue sealing often fails even with small pressures; the application needs extra care.





Suggestions for improvement:

- Work on sealing: trying different glues and precision application.
- Find a pressure control device for the fluid inlets.
- Use microscope-aided observation for the handling of the interfaces.

The gluing and pressure control didn't allow us to produce quality gels. However, this method presents the greatest potential.

Conclusion

Overall, we observed that the syringe experiment was initially successful, as were able to produce quality gels using simple methods. Despite the mixer's failed tryout, these two tests set the groundwork for the miniaturization and size control of our fabrication cycle, as we were finally brought into conceiving the microfluidic device that we believe has the greatest potential for future application. Using a clean gluing process and pressure control of our fluids, this device can enable us to produce the gels we are looking for through extensive experimentation, and perhaps even CFD simulations.

References

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- [2]**Rhutesh K. Shah, Jin-Woong Kim, Jeremy J. Agresti, David A. Weitz, Liang-Yin Chu:** Fabrication of monodisperse thermosensitive microgels and gels capsules in microfluidic devices. Royal Society of Chemistry, 2008
- [3]**Su Hung Ching, Nidhu Bansal, Bhesh Bhandari:** Alginate gel particles – A review of production techniques and physical properties. Science and Nutrition, 2017