Ingestible Device for Ultra-long Lasting Drug Releasing in the Stomach

Mahika Nagaradona, Wanrong Xie, Wubin Bai

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Abstract

Bioengineered yeast are widely used for biocompatible drug delivery. However, the shelf life of the yeast was not long enough to help with treatment. Herein, we developed an orally ingestible device with ultra-long drug-releasing capabilities. The device consists of a capsule with a biocompatible polymer that hosts yeast that produces therapeutic proteins. The capsule will adhere to the gastric walls through a biocompatible adhesive. Drug releasing will occur passively through the dissolving of the capsule in the stomach and allow for the yeast to produce therapeutic proteins to help with the treatment of chronic diseases such as PKU.

Design

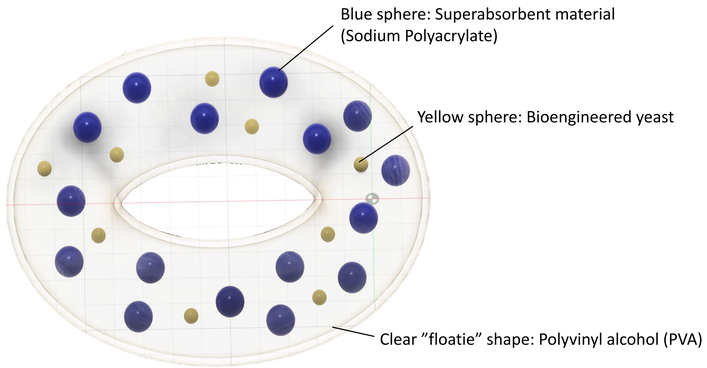

Fig. 1. Illustration of the orally ingestible device

Fig. 2. Image shows a representation of what orally ingestible device will look like inside of the pill capsule.

- The device consists of two layers an outer pill layer and an inner layer of PVA, superabsorbent material, and bioengineered yeast.
- The idea is that the PVA will act as a protective layer where it will host the superabsorbent material and the bioengineered yeast.
- When the pill capsule enters the body orally it will travel down to the stomach where it will dissolve and expose the PVA which is adheres to the stomach walls.
- The PVA layer will have micro holes in it to allow for water to pass through and make contact with the superabsorbent material.
- The superabsorbent material will expand and allow for the bioengineered yeast to produce therapeutic proteins to treat PKU.

Results

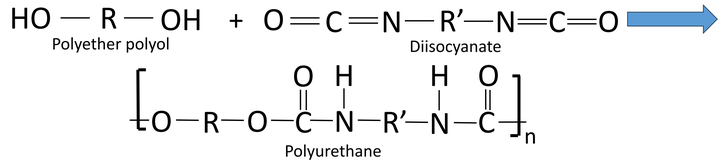

Fig. 3. Chemical Structure of Polyurethane Foam

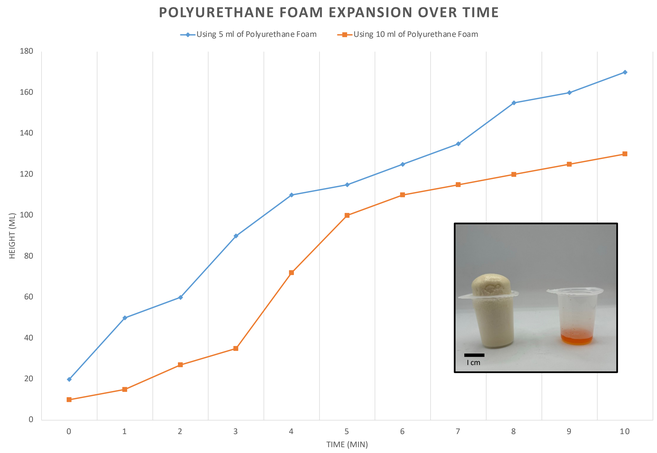

Fig. 4. This graph shows the expansion rate of the polyurethane foam in a span of 10 minutes for both 5 and 10 ml being used. Inset: Image shows the expansion of the polyurethane foam in comparison with the original amount put in the beaker.

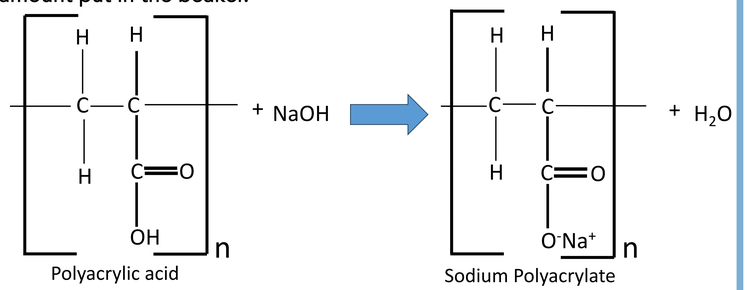

Fig. 5. Chemical Structure of Sodium Polyacrylate

Fig. 6. Image shows the expansion of superabsorbent material from powder state to gel state when water is added.

- Tested two different polymers, polyurethane foam and superabsorbent material which will be put inside the PVA to host the bioengineered yeast
- The superabsorbent material is biocompatible and is more flexible
- Polyurethane hardens once it has fully expanded making it difficult to dissolve in the body
- The superabsorbent material can be triggered to expand by water which will allow for a controllable trigger while the polyurethane foam is triggered by the mixing of parts A and B which is harder to control in the body.

Results

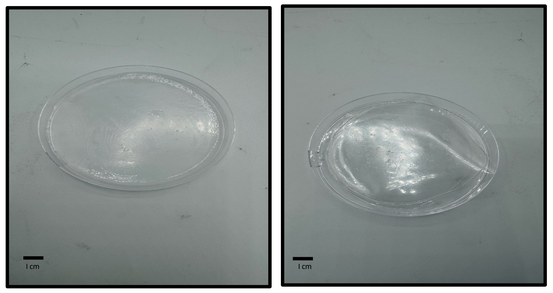

Fig. 7. Image shows the PVA solution after being frozen for 8 hours and then thawed out for 3 hours versus the PVA after being annealed at 100° C. The PVA on the right is stretchable which is what we need so we will be able to form the “floatie” shape.

Conclusion

- We developed an orally ingestible device for ultra-long-lasting drug release in the stomach, our device will help with the treatment of PKU
- The sodium polyacrylate (superabsorbent material) allows for maximum potential of long-lasting drug delivery
- It can expand in contact with water allowing for natural triggering
- The chemical properties of the superabsorbent material allow it to host the yeast

Future development

- Continue working on the fabrication of the device implementing the ”floatie” shape to allow for ultra-long-lasting drug delivery by working on the molecular design of the PVA.
- After fabrication is complete, experiment with in vivo evaluation of the device through animal models and test out how the expansion of the superabsorbent material works.
- Test the effectivity of the drug delivery system and see if there is a difference through therapeutic protein treatment for PKU.
- Develop a way to optimize gastric residence to allow for the device to exit the body once completed with it’s the drug delivery cycle.

References

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3. Ates, Murat, et al. "Polyurethane foam materials and their industrial applications." Polymer International 71.10 (2022): 1157-1163.