Team PILLS

Pharmaceutical Innovation through Laser Lithography Strategies

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Introduction

- The Human Immunodeficiency Virus (HIV) is an autoimmune condition in which the immune system is destroyed by white blood cells
- Developments in treating HIV rely on controlled release technology
- The active ingredient can be released throughout the course of two months and drug levels in the bloodstream stay in the therapeutic window
- A constant release rate can be problematic for children who need a release rate that accounts for their growth and increasing metabolism

Problem Statement: Limited research has been conducted on biodegradable capsules and controlled release. Our research aims to fill this gap.

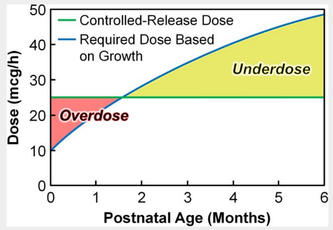

Figure 1: Graph of the effects of standard dosing during child growth and development

Research Goal

- 3D nanoprint biodegradable medicine-filled capsules for controlled therapeutic drug delivery
- An army of capsules that will each release on a different time scale for an overall constant release

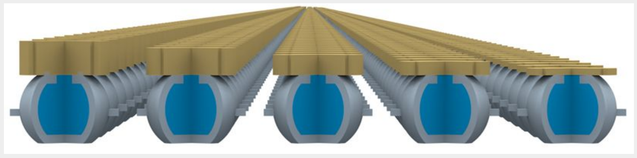

Figure 2: Controlled rate of drug release by deploying a mixture of capsules with variable cap thicknesses

Materials and Methods

- Microfluidic Multi-Material Direct Laser Writing with the Nanoscribe Photonic Professional GT2 DLW 3D printer for capsule printing
- DEGRAD INX from BIOINX is the shell material
- PEGDA is the cap material
- The Zeiss Axio Observer Z1 microscope and ZEN 2 computer software were used to analyze our samples

Data Collection

- Our experiments are aimed at developing a model for the degradation of the cap material
- We printed the material in a range of thicknesses and performed degradation tests under acidic and basic conditions (1 M HCl and 1 M NaOH)

Analysis

Degradation Rate

- Initial results for the rate of dissolution of the biodegradable cap material show that the cap has swelling properties, which can result in diffusion
- For the shell material, it hasn't yet degraded in a time period that we were able to measure
- We are currently running further tests to assess the degradation rate for the shell material

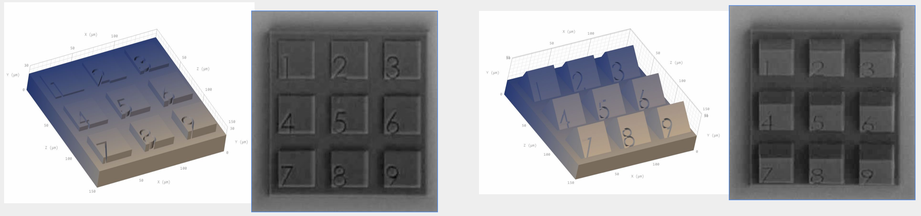

Figure 3: CAD model and microscope images of prints using DEGRAD INX with varying thicknesses used for degradation tests.

Vacuum Loading

- Successfully 3D printed the shell; however, we had difficulty in aligning and printing the caps on top
- Rhodamine (a chemical compound and red dye) was vacuum loaded into the shells and the fluorescent microscope images show that it stays in the closed shells

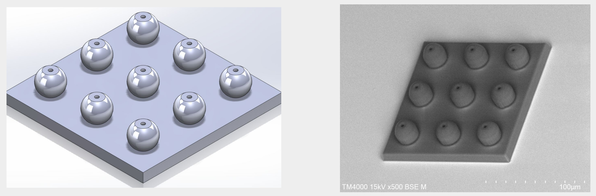

Figure 4: CAD model and print of shell array prepared for the liquid core drug loading step

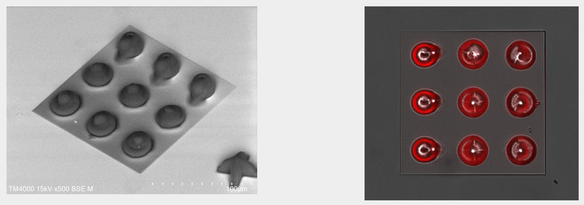

Figure 5: Microscope images of shells after drug loading and cap printing

Modeling

- With limited access to the nanoscribe at UMD, a portion of the work has been focused on modeling and simulations
- Models were created using Comsol
- The chemical and fluid interactions will be modeled through Comsol once the degradation rate is determined

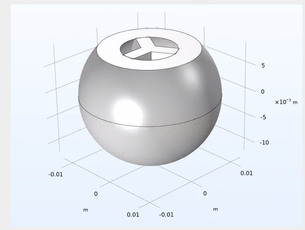

Figure 6: CAD model of pill shell loaded into COMSOL workspace

Future Research Goals

1. Determine the rate of degradation, as the cap material has been mostly unresponsive thus far
2. Find a material that is more readily dissolvable in the acidic and basic environments
3. Address compartmentalization of the biodegradable pills
4. Apply this technology to a wide range of medical settings, such as cancer treatment

Acknowledgements

Thank you to our mentor Dr. Ryan Sochol and the BAM Lab, Jack, Dr. Sunandita Sarker, Dr. Sharon Flank, Dr. Stephen Hoag, our Librarian Ms. Nedelina Tchangalova, Dr. David Lovell, Dr. Allison Lansverk, and the Gemstone Staff. To learn more visit our website: https://gemstoneteampills.wixsite.com/pills

References