THE KENNEDY LAB
Laboratory for Electromagnetically Inspired Biomaterials and Biosystems

THE UNIVERSITY OF RHODE ISLAND

Pharmacy Room 410
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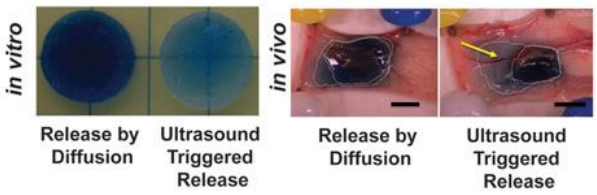
Platform System for Regulating the Power Density and Duration of Ultrasonic Signals

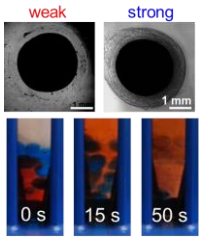
Overview:

The Laboratory for Electromagnetically Inspired Biomaterials and Biosystems aims to develop new paradigms in gene & drug delivery, tissue engineering, wound healing, cancer therapies, pain management, and orthopedics using simple, but powerful electromagnetic principles as inspiration. One of our systems involves implantable biomaterials that can be instructed to release drugs from within a patient's body, when stimulated remotely with ultrasonic waves. Essentially, we are developing bio-compatible materials for remote-controlled drug delivery. These ultrasonically responsive biomaterials have already been demonstrated to release drug in response to ultrasonic stimulus in multiple formats (see figure at right). Drugs can be loaded into bulk hydrogels or capsules (or capsules integrated into bulk hydrogels) and triggered to release their payloads at various ultrasonic power densities and durations. However, many therapies require sequenced delivery of multiple drugs. We believe these ultrasonically responsive drug delivery materials can be engineered to respond to ultrasonic signals of various amplitudes and durations, which can be utilized for sequenced delivery of multiple bimolecular payloads. In order to test this hypothesis, we will need a system capable of delivering ultrasonic signals with flexible power densities and durations.

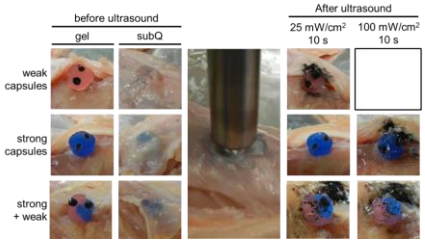
Ultrasonic release from bulk hydrogels



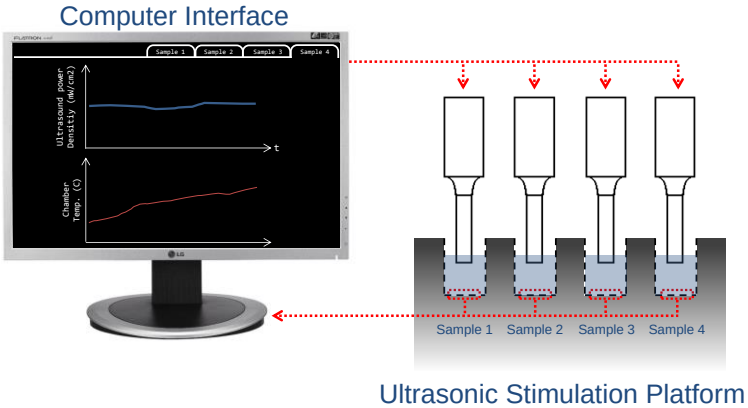
… from capsules



… from capsules integrated in bulk gels



System Diagram:



Specifications:

- Ultrasonic stimulation platform
  - Expose at least 4 samples in an aqueous solution to ultrasonic signals whose power densities are between 0 and 1 W/cm^2 and c ontrol the duration of stimulation.
  - Maintain sample temperatures within 5°C of ambient.
  - Measure the ultrasonic power density and temperature as a function of time for each sample and stream this data to the Computer Interface
  - Receive instructions from the Computer Interface regarding the ultrasonic power density and duration of ultrasonic exposure.
- Computer Interface
  - Provide a graphical interface for the user to input desired ultrasonic power densities and durations.
  - Be capable of providing programmable ultrasonic stimulation regiments with flexible and variable power densities and durations over a 1 month period.
  - Receive measurement data from the Ultrasonic Stimulation Platform and plot/present them as indicated by the user (e.g., average over time, plotted vs. time, etc.).
  - Provide easy transfer of data to document files on computer (e.g., Excell files).
  - Serve as a controller for the Ultrasonic Stimulation Platform.

Team Description:

- 1 Electrical Engineer and 1 Computer Engineer
- Strong drive, work ethic, independence, and resilience to troubleshooting are a must.
- Experience with machining hardware and interfacing with Labview are a big pluses.
- Experience and interest in ultrasound is a big plus.
- The desire to expeditiously develop this system so that the student(s) can start using this system to conduct drug delivery experiments is a big plus.

Team Division of Labor:

Electrical Engineer 1. This engineer will design and build the Ultrasonic Stimulation Platform. He/she will be responsible for developing a system capable of delivering ultrasonic signals of various power density and duration to at least 4 samples while maintaining a relatively stable operating temperature. Additionally, he/she will design the system so that the real-time ultrasonic power density and temperature can be accurately measured for each sample. Finally, he/she will work with Computer Engineer 1 to appropriately interface the Ultrasonic Stimulation Platform with the Computer Interface.

Computer Engineer 1. This engineer will develop a computer interface for transmitting to and receiving information from the Ultrasonic Stimulation Platform. This computer system must provide a clean user graphical interface that allows the user to control the system's ultrasonic power density and have a programmable setting to control regiments of ultrasonic stimulation over a 1-month period. He/she must also design the Computer Interface to observe received data in the manner specified by the user. All system calculations for proper functioning (e.g., regulation of temperature) are to be calculated by the Computer system.

If you have any questions about the project, its objectives, or any of the abovedescribed roles, please contact Prof. Steve Kennedy: skennedy@ele.uri.edu

For further reading see: (1) http://www.pnas.org/content/early/2014/06/23/1405469111
(2) http://www.nature.com/nmat/journal/v12/n11/full/nmat3758.html