CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

S0699

Project Title

Novel Nanoscale Approach to Combat Disease: Electrically Stimulated Drug Release from Biodegradable PCL Nanofilms

Abstract

Objectives/Goals

Today, drugs are administered orally or injected. Such methods distribute drugs systemically, resulting in low drug efficacy and side effects. To solve this, scientists have been developing stimuli-responsive nanocarriers that release drugs at targeted areas in response to external stimuli. An exciting research area is nanocarriers that release drug in response to electric stimuli. Current systems for electroresponsive drug release either use dangerous voltages (-5 to -15 V) or are non-biodegradable. My project goal was to develop a drug delivery system that is both biodegradable and uses safe voltages (-0.5 to -1 V) to trigger drug release.

Methods/Materials

I focused on a biodegradable, FDA-approved polymer called Polycaprolactone (PCL). I synthesized a nanofilm of PCL loaded with Fluorescein (FL), a model drug, then studied if the nanofilm had electroresponsive drug release capabilities.

Results

Drug release experiments demonstrated that the nanofilm had electroresponsive release capabilities. Voltages as low as -0.7 V resulted in greater FL release from the film compared to passive release. Drug release also increased in a linear, predictable fashion with increasing number of stimuli and increasing voltage. After the electroresponsiveness of the nanofilm was confirmed, I investigated the release mechanism. The electrode on which the film was formed increased in pH upon electric stimulation, and drug release increased in basic pH solutions. I hypothesize that the primary drug release mechanism is the accelerated hydrolysis of ester bonds in PCL catalyzed by the local pH increase due to electric stimulation.

Conclusions/Discussion

I envision my PCL nanofilm to be incorporated in a recently-developed ultrasonically-powered implant that can wirelessly stimulate electroresponsive drug release in the body. While this implant is not biodegradable, researchers have developed biodegradable electronics, which could be used to make the implant fully biodegradable. This drug delivery system would increase drug efficacy and enable more precise drug regimens (temporal/dosage control). It is convenient and safe, in part due to its biodegradability (ability to disintegrate in the body). This system could revolutionize the treatment of chronic diseases like cancer. To the best of my knowledge, this is the first demonstration of an electroresponsive drug delivery system that is sensitive to low voltages and biodegradable.

Summary Statement

I created a novel nanofilm composed of PCL loaded with a model drug. This is the first demonstration of a drug delivery system that is biodegradable and electroresponsive at low voltages.

Help Received

I would like to thank Devleena Samanta, Katy Margulis, and Professor Richard N. Zare at Stanford University for mentoring me throughout the project and providing me the opportunity to carry out my research in their lab.