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

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Oral and intravenous methods of drug delivery distribute drugs systemically, resulting in low drug efficacy and side effects. Thus, polymeric nanocarriers that can target drug release in response to external stimuli have been developed. An exciting new research area is drug release triggered by electric stimuli. Current electroresponsive drug release systems either use dangerously high voltages or are non-biodegradable. It is thus of interest to develop a system that is biodegradable and uses safe voltages (<-1 V) to trigger drug release. In this research, I designed and synthesized a nanofilm composed of a biodegradable, FDA-approved polymer called polycaprolactone (PCL). Drug release experiments demonstrated that the nanofilm has electroresponsive drug release capability. Voltages as low as -0.7 V resulted in significantly increased drug 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. I moreover investigated the release mechanism. Experiments suggest 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. In the future, my PCL nanofilm could be incorporated into a recently-developed ultrasonically-powered implant that can wirelessly stimulate electroresponsive drug release in the body. This drug delivery system would increase drug efficacy, enable more precise drug regimens (temporal/dosage control), and be convenient and safe. It could revolutionize the treatment of chronic diseases like cancer. In summary, this is the first demonstration of a drug delivery system that is biodegradable and electroresponsive at low voltages.

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