

Wireless Feedback-Controlled Drug Delivery Pumps for Small Animal Research

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Biomedical microelectromechanical systems (bioMEMS) enables microfabricated devices for next generation drug delivery applications. Specifically, advanced devices suitable for use in small research animals that can provide on-demand delivery of drugs directly to the site of therapy are not currently available. Most laboratory studies involving drug administration in small animals are conducted using needle injection and therefore involve manual animal handling. Existing technologies for drug delivery in small animals are also insufficient. External pumps require tethers that impede animal movement and suffer from risk of entanglement. Implantable pumps include peristaltic and osmotic pumps but feature only limited drug payload and device lifetime, slow infusion, and limited delivery modes. To achieve chronic administration of drug with only a single surgical procedure, wirelessly-operated bioMEMS pumps were developed. These pumps feature on-demand dosing with operation over a wide dynamic range of flow rates, remote and wireless operation, accurate electrolysis-based pumping, a refillable drug reservoir, miniature form factor, and broad drug compatibility. In addition, these pumps have been integrated with sensors for electrochemical dose measurement that enables closed-loop drug delivery. Accurate, real-time tracking of drug dose and on-the-fly flow rate adjustments were demonstrated. The sensing method was also successfully applied to leak and occlusion detection. To date, there are no implantable closed-loop pumps for small animal research. Our advanced bioMEMS pumps achieve chronic temporal and spatial control of delivered compounds to maximize bioavailability and therapeutic efficacy.