Organic electronic materials, that is, carbon-based compounds that conduct electricity, have emerged as candidates for improving the interface between conventional electronics and biological systems. The softness of these materials matches the elasticity of biological tissue better than conventional electronic conductors, allowing better contact to tissue, and the mixed ionic-electronic conductivity can improve the signal transduction between electronic devices and electrically excitable cells. This improved communication between electronics and tissue can significantly enhance, for example, electrical stimulation for therapy and electrical recording for diagnostics.

The ionic conductivity of organic electronic materials makes it possible to achieve ion-specific ionic currents, where the current consists of migration of specific ions. These ions can be charged signalling substances, such as neurotransmitters, that can selectively activate or inhibit cells that contain receptors for these substances. This thesis describes the development of chemical delivery devices, where delivery is based on such ion-specific currents through ionically and electronically conducting polymers. Delivery is controlled by electrical signals, and allows release of controlled amounts of neurotransmitters, or other charged compounds, to micrometer-sized regions.

The aims of the thesis have been to improve spatial control and temporal resolution of chemical delivery, with the ultimate goal of selective interaction with individual cells, and to enable future therapies for disorders of the nervous system. Within the thesis, we show that delivery can alleviate pain through local delivery to specific regions of the spinal cord in an animal model of neuropathic pain, and that epilepsy-related signalling can be suppressed in vitro. We also integrate the delivery device with electrodes for sensing, to allow simultaneous electrical recording and delivery at the same position. Finally, we improve the delay from electrical signal to chemical delivery, approaching the time domain of synaptic signaling, and construct devices with several individually controlled release sites.