An electrochemical pump using blackened platinum electrode for rapid microadministration of neurotransmitter toward neuron

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Introduction

Improving the resolution of artificial sensory organs requires an interface that receives external information from electronic circuits and stimulates appropriate neurons individually in response to that information. The method of traditional electric stimulation in present artificial sensory organs is fairly nonselective and damaging for neurons. Technology for rapid and selective stimulation of neurons is strongly needed for artificial sensory organs. Then, we developed a method of chemical stimulation of neurons using a neurotransmitter by means of an electrochemical micropump powered by the bubbling created by water electrolysis applying Suzuki's method[1)]. Blacken platinum wires were used for electrodes for the electrolysis. The bubble generated by the electrolysis can disappear rapidly on the blacken platinum electrode soon after the stop of the electrolysis. Then the jet of the inner solution from the pump is controllable by the voltage application to the electrode.

Experimental

The structure of the electrochemical pump is shown in **Figure 1**. The micropump contains a glass nozzle with a tip 10 µm in diameter. Two blackened platinum electrodes for the electrolysis are inserted into the body of the pump which is filled with neurotransmitter solution. The distance between a neuron of the gastropod *Aplysia* and the tip of the nozzle was adjusted to *ca*. 100 µm. Voltage of 3.0 V was applied to the electrodes to jet out the solution toward the neuron while monitoring its membrane potential.

Results and Discussion

Administration of 10 mM acetylcholine to a resting neuron generated neural firing only when voltage was applied for 0.5 s without time lag as shown in **Figure 2**. Spontaneous firing of active neurons was inhibited by administration of 50 mM γ-aminobutyric acid (GABA) with a time lag of approximately 1 s. The time of inhibition of the firing was approximately 10 times longer than the time of the electrolysis voltage application. Modulation of voltage application time is needed for more precise inhibition of neuron firing (**Figure 3**).

Conclusion

We conclude that neurotransmitter administration using the electrochemical micropump enables real-time control of excitation and inhibition of neurons as designed. The simple pump is easy to downsize, and so is promising for creating potential experimental tool for neuroscience or artificial synapses in artificial sensory organs.

Reference

1) H. Suzuki, R. Yoneyama: A reversible electrochemical nanosyringe pump and some considerations to realize low-power consumption. *Sens. Actuators B: Chemical*, **86**, 242-250 (2002)

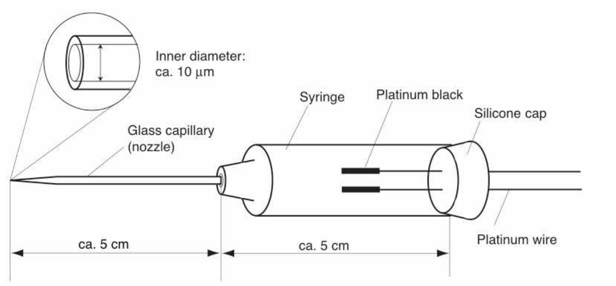

Figure 1: Structure of the micropump

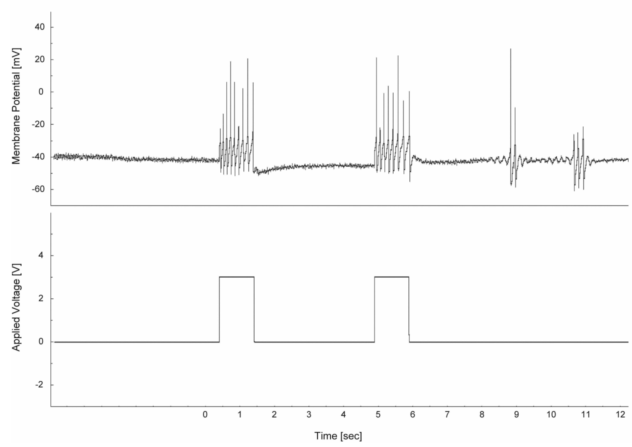

Figure 2: Response in membrane potential of a resting neuron against voltage application to the electrode in the micropump containing acetylcholine

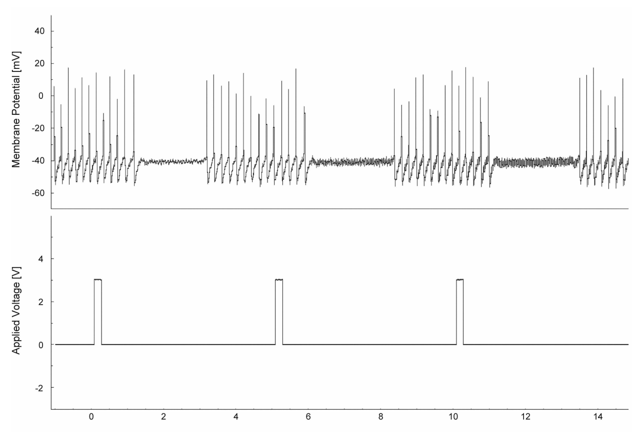

Figure 3: Response in membrane potential of an active neuron against voltage application to the electrode in the micropump containing GABA.