

On the Laboratory Synthesis of Electric Eel Electrocytes

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Abstract

This paper explores the experimental simulation of electric eel cells. By simulating the electrochemical conditions found within eel electrocytes on a macroscopic scale, this experiment was able to produce significant voltages ranging in the hundreds of millivolts. Specifically, this experiment employed the use of sodium alginate, an organic salt that releases Na⁺ ions in water, to simulate the release of sodium ions in electrocytes. By using dialysis tubing with a specific pore size, it was possible to trap the alginate while allowing the diffusion of Na⁺, thereby creating a charge differential across the tubing and inducing a measurable voltage. **Keywords:** [keywords]

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1 Introduction

Native to the freshwater rivers of South America, the *Electrophorus electricus*, or more commonly referred to as the electric eel, is known for its ability to generate high voltage shocks, formally known as electric organ discharges (EOD); these EODs can be classified into low-voltage EODs and high-voltage EODs. Low-voltage EODs are expressed at lower frequencies of about 10Hz to 20Hz [4], reaching about 10 V [5]. Therefore, they are more practical for communication and determining the presence of organisms in their environment through a process called electrolocation: monitoring changes in a particular electric field [1]. On the other hand, high-voltage EODs are used as an attack or defence mechanism, the largest recorded voltage discharge being 500V [5]. However, whether the emitted EODs are expressed as low or high voltages, they are produced from a specific cell that makes up 80% of the eel's body: electrocytes [3]. These electrocyte cells are arranged in series and in parallel and are located in the electric eel's three most prominent organs: Sach's organ, the Main organ, and Hunter's organ [5]. [cite this figure (Figure 1.)] This arrangement allows for the entire eel to be viewed as a battery, with the positive and negative poles at the head and tail respectively, allowing for the variety of EOD voltages mentioned above. Although electric eels have the potential to release high-voltage EODs, the current produced remains nonetheless quite minimal (1 A) [5]. This is a result of the high resistance of the freshwater where these eels are found, or more precisely, the lack of ions to maintain the electric current [2]. Consequently, to optimize the battery potential of the electric eel's EOD, research was conducted by Lina Guezi [6], a colleague of ours, to produce a synthetic replication of the electric eel's electrocyte cells in ionized water. Our experiment aims to test their research findings by making our own battery prototype based off of their work with a few modifications in order to explore the potential uses of this biological battery. To do so we used a dialysis membrane to isolate positive sodium ions (Na^+), similarly to how the electric eels do in their electrocyte cells, which creates a potential gradient across our synthetic electrocyte cell. This process generates a voltage difference which then produces an electric discharge.

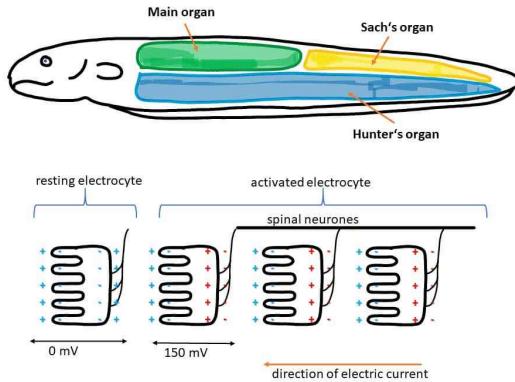


Figure 1: Electric eel's organ composition (Hunter's organ, the Main organ, and Sach's organ make up 80% of the eel's organs) with electrocyte cell alignment and polarization.

2 Material and Methods

Materials

- Drinking glasses or other receptacles capable of holding water
- Dialysis tubing with a MWCO of 6-8kDa
- Sodium alginate powder
- Voltmeter
- Alligator wires



Figure 2: Experiment with aluminium foil attached to electrode

Method

1. Drinking glasses were rinsed and filled with hot tap water. Roughly 10cm pieces of dialysis tubing were cut, and one piece of tubing was soaked in each glass for 30 minutes.
2. Dialysis tubing pieces were removed from the water, opened up, and a knot was tied at the bottom of each piece, sealing it. 1.25mL of sodium alginate powder was inserted into each section of tubing, and the tubes were filled around 3/4 of the way with water to dissolve the powder. Stirring rods were used to aid soaking and dissolution of the powder.
3. The filled dialysis membranes were placed back into their glasses, open side up, ensuring that the top of each piece protruded past the water level in the glasses.
4. The setup was left for 12 hours to maximize ionic diffusion.
5. The voltage of each sample was measured by placing two alligator-clip wires in each glass: one wire was placed inside the dialysis tubing, and one was placed in the glass but outside the tubing. The positive probe of the voltmeter was then attached to the wire outside the tubing, and the negative probe was connected to the wire inside the tubing. A reading was then made using the voltmeter and the data was recorded. This was repeated for each replicate.

3 Results and Discussion

References

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Figure 3: Membranes being left to diffuse

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