1-11-2024

A Novel, Sponge-Tipped Electrode for Motion-Artifact-Tolerant Recording of High-Quality Electroencephalogram Signals

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Introduction

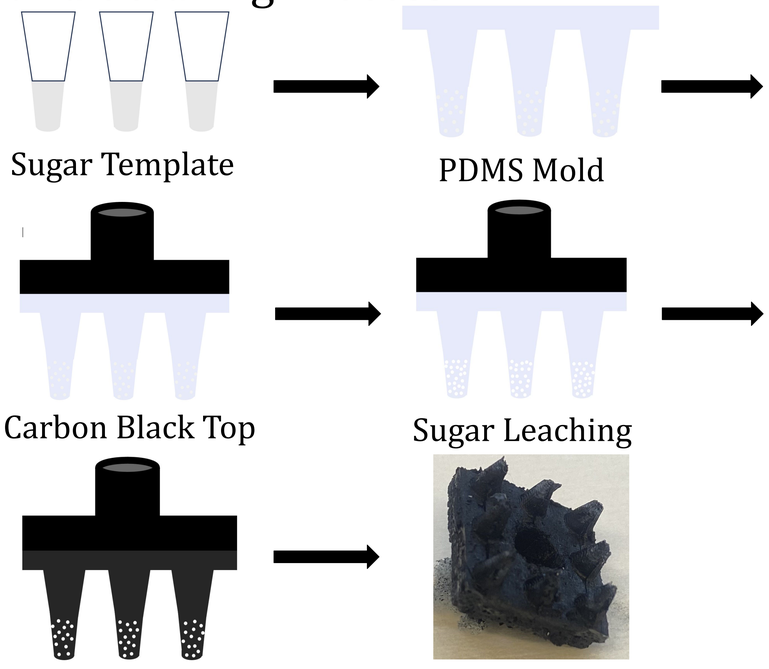
Electroencephalography (EEG) is the recording of electrical activity along the scalp produced by the electrical excitement of neurons within the brain. EEG is a non-invasive method used to detect and record brainwave patterns for recognition of brain function, sleep patterns and diagnosis of various neurological disorders

Commercial EEG electrodes face disadvantages such as…

- Susceptibility to Motion Artifacts
- Limited Comfort
- Limited Scalp Contact
- Inconvenience during Prolonged Use

Our design combats all these disadvantages when using conductive gel through the use of 1) a porous, sponge tip and 2) a pillar structure for electrode contact to the scalp.

Manufacturing Process



Data and Results

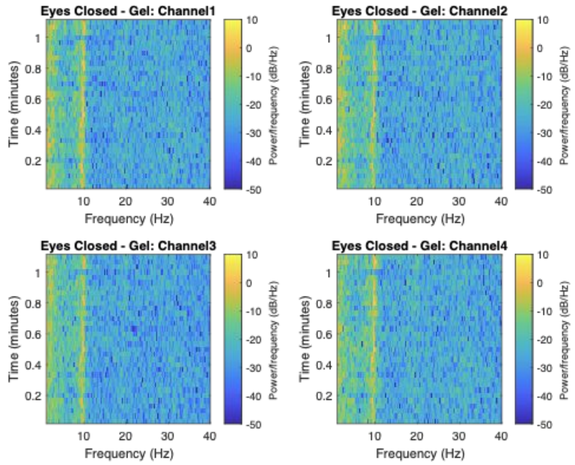


Figure 1: Time vs Frequency Analysis of Sponge Electrode to Commercial Electrode in Gel Conditions with Eyes Closed

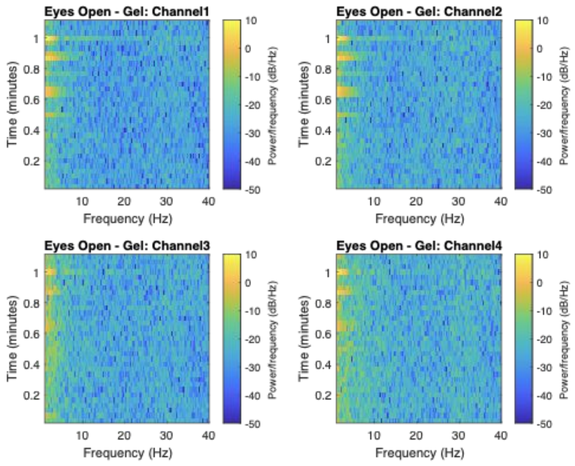


Figure 2: Time vs Frequency Analysis of Sponge Electrode to Commercial Electrode in Gel Conditions with Eyes Open

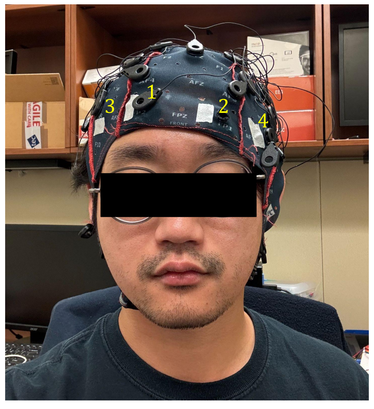


Figure 3: Location of Electrode on EEG Headset for each Channel on Research Participant

- Channels 1 and 2 are used for data taken from our novel, sponge-tipped electrode
- Channels 3 and 4 are used for data taken from commercial electrodes

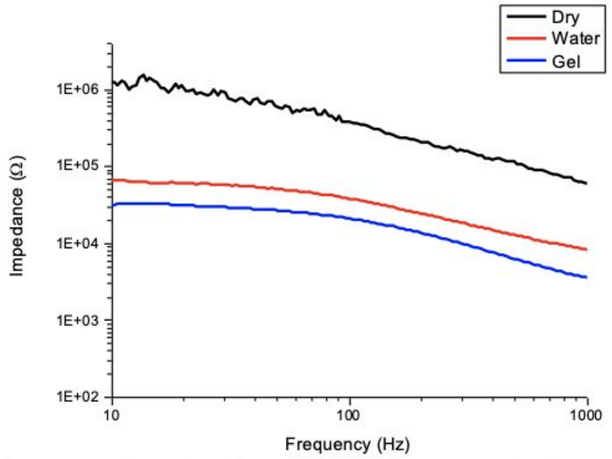


Figure 4: Impedance Analysis of Sponge-Tipped Electrode using Bode Analyzer

Table 1: Impedances Values for Electrode Comparison

	Ag - Sponge	Ag - Polymer	Ag - Au
Dry	1.23E+06	1.05E+06	3.16E+05
Dry (Hard)	2.76E+05	6.79E+05	2.26E+05
Water	6.47E+04	6.57E+04	7.35E+04
Gel	3.18E+04	8.95E+04	5.89E+04

Conclusions

Our electrode's soft and flexible design presents a viable solution to challenges posed by traditional, commercial electrodes, making it a valuable tool for real-world EEG applications.

Future works may include…

- Long-Term Performance Studies
- Material and Fabrication Optimization
- Clinical Validation

References

[1] Zhang, L., Kumar, K.S., He, H. *et al.* Fully Organic Compliant Dry Electrodes Self-Adhesive to Skin for Long-Term Motion-Robust Epidermal Biopotential Monitoring. *Nat Commun* 11, 4683 (2020). https://doi.org/10.1038/s41467-020-18503-8
[2] Lo, L.W., Zhao, J., Aono, K., *et al.* Stretchable Sponge Electrodes for Long-Term and Motion-Artifact-Tolerant Recording of High-Quality Electrophysiologic Signals. *ACS Nano* 16 (8), 11792-11801 (2022). https://pubs.acs.org/doi/10.1021/acsnano.2c04962?ref=pdf

Special thanks to Chansoo Kim, Junyi Zhao, Naiyan Wu, Jiheng Zhang, and Tong Wu

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