Mechanically Robust Superhydrophobic Coatings via Dual-Step Deposition for Electrodermal Activity (EDA) Electrodes Immersible in Saltwater

Dong-hee Kang†, *, Andrew G. Peitzsch†, Youngsun Kong, and Ki H. Chon*
Department of Biomedical Engineering, University of Connecticut

UCONN COLLEGE OF ENGINEERING BIOMEDICAL ENGINEERING

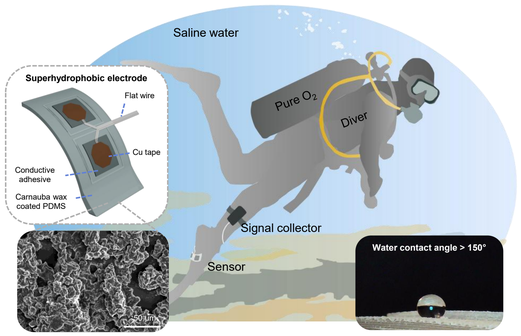
MHSRS 2026

BACKGROUND

High Risk: Divers breathing 100% O_2 face critical risks of Central Nervous System Oxygen Toxicity (CNS-OT).

Predictive Marker: Electrodermal activity (EDA) serves as a key physiomarker, showing marked amplitude increases before CNS-OT symptoms.

Underwater electrodermal activity (EDA) sensing

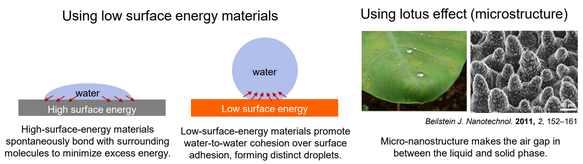


Technical Barrier: Aquatic monitoring requires hydrophobic electrodes, but seawater introduces severe ionic interference.

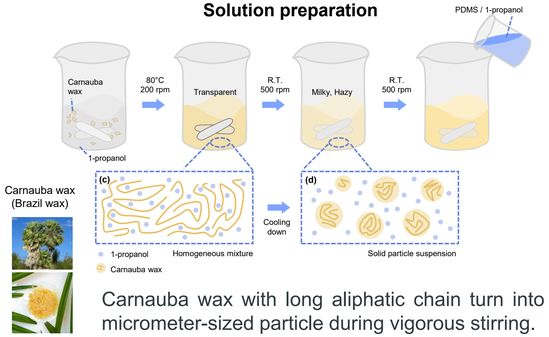
Key point 1: Demonstrate underwater EDA monitoring

Key point 2: Fabrication of mechanically robust superhydrophobic coating

Mechanisms of Hydrophobic Surface Formation



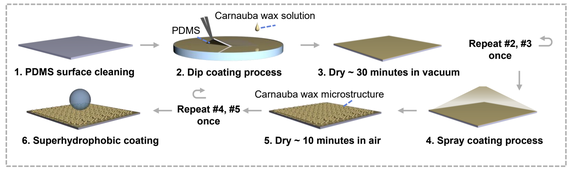
Solution preparation



Carnauba wax with long aliphatic chain turn into micrometer-sized particle during vigorous stirring.

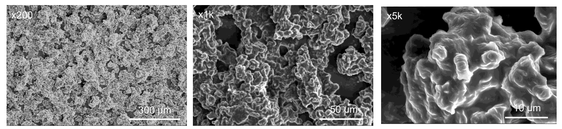
METHODS

Coating process



- The fabrication method consists of two main processes: dip coating and spray coating.
- Dip coating primarily facilitates particle adhesion to the substrate, while spray coating enhances the formation of hierarchical microstructures.

Scanning electron microscope (SEM) image of coated surface

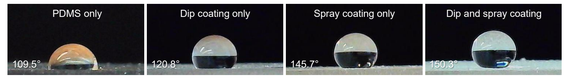


- Combined two different coating forms multi-layered microstructures on the scale of tens of micrometers.

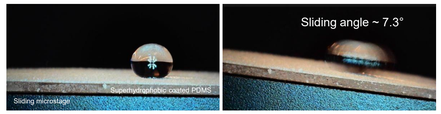
RESULTS

- A surface is classified as superhydrophobic if the static water contact angle exceeds 150° and the sliding angle is less than 10°.

Water contact angle (WCA)

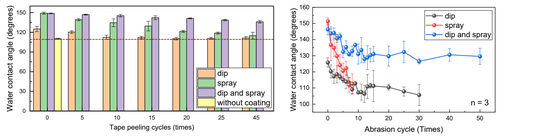


Sliding angle (SA)



- Surface energy of coating is the lowest at spray coating – dip and spray showed the best performance at hydrophobicity.

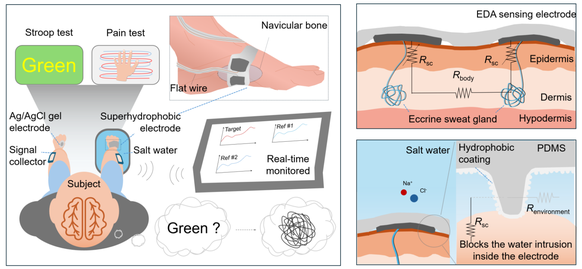
Mechanical robustness test



- Dip and spray coating method showed excellent durability over two different tests (Tape peeling test, sandpaper abrasion test).

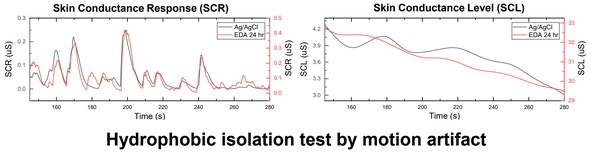
EDA measurement

Experiment protocol and principles of measurement

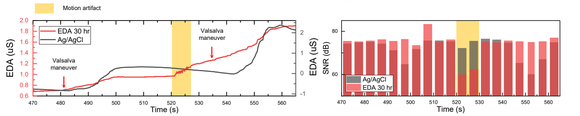


- Fabricated electrode was tested inside saltwater and compared with gold-standard Ag/AgCl gel electrode in air.

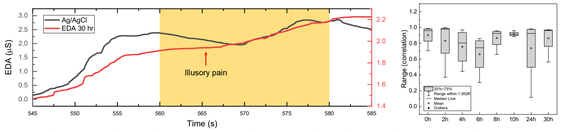
After 24 hours of saltwater immersion of the electrode



Hydrophobic isolation test by motion artifact



Thermal induced pain test

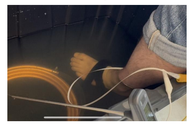


- Even after long-term immersion in saltwater, the sensor showed excellent performance (Pearson correlation > 0.5).

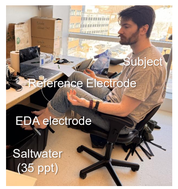
Consecutive EDA monitoring for 7 hours

Mental math

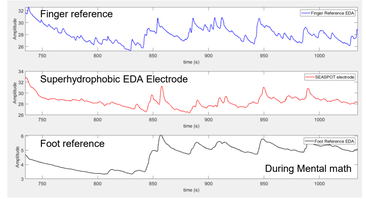
Electrode submerged in saltwater



Experiment video



❖ EDA Signals after 7 hours of submersion



DISCUSSION

- **Novelty in Saltwater Hydrophobicity**

Addressed the understudied field of high-salinity superhydrophobicity by developing a mechanically robust coating that withstands long-term, repeated saltwater immersion.

- **High-Fidelity Aquatic Monitoring**

Secured long-term operational stability in harsh marine environments, ensuring reliable and continuous physiological signal collection without degradation.

- **Diver Safety via CNS-OT Prediction**

Successfully implemented a highly reliable wearable sensor for divers, enabling early, real-time prediction of CNS-OT-induced seizures during undersea operations.

- **Broad Applicability in Extreme Environments**

Provides a versatile and scalable framework for engineering next-generation wearable sensors (e.g., ECG, EMG, EOG and EEG) that require reliable performance in extreme marine or high-pressure conditions.

MORE INFORMATION

Use this QR code to view more information about this research.

Dong-hee Kang
University of Connecticut
Contact : dong-hee.kang@uconn.edu

REFERENCES

Kang, D.-h., Peitzsch, A. G., Kong, Y., Jimenez-Wong, C., Lee, Y., Abraham, Z. A., Florian, J. P. A., and Chon, K. H., Mater. Des. **2026**, *267*, 116359.

Image credit

- *Beilstein J. Nanotechnol.* **2011,** *2,* 152–161
- https://www.britannica.com/plant/palm-tree/Ecology
- https://naturalpoland.com/en/products/waxes/carnauba-wax/

ACKNOWLEDGMENTS

This work was supported by the Office of Naval Research, DHA23B-003, Phase II SBIR program.