Tellurene-based wearable electrochemical sensor (TWEETs) for longitudinal quantification of neurotransmitters in human sweat

Tellurene-based wearable (TWEET) quantifies dopamine and norepinephrine in sweat in real time with nM sensitivity and high selectivity.

Researchers at Purdue University have developed a tellurene-based wearable electrochemical sensor (dubbed TWEET) that can quantify the concentration of neurotransmitters (NTs) in human sweat in real time, the first sensor of its kind to do so. NTs are small molecules used by neurons to signal different types of information to neurons or other target cells; abnormalities in this process are related to different neurological diseases and mental health issues. Currently, there exists no way to monitor the level of NTs in real time, and the analytical methods used to quantify NTs require large, complex, labor-intensive, and typically very expensive instruments such as liquid chromatography with mass spectrometry (HPLC/MS), micro dialysis, fluorescence microscopy, electrophoresis, and colorimetric analysis. Additionally, none of the analytical methods provide adequate time-resolution to really understand the processes going on within the body that are associated with NTs, which tend to be released on the timescale of milliseconds. If individuals or patients had the ability to longitudinally monitor their NT levels in real time, it would allow for health professionals to find patterns in NT levels and correlate that with different behaviors, treatments, or health outcomes to assist with diagnosis.

The Purdue researchers developed a wearable tellurene-based sensor patch to measure the concentration of dopamine (DA) and norepinephrine (NE) in human sweat in real time, the first wearable sensor to do so. The TWEET sensor made use of a Bluetooth-enabled potientiostat that measured the voltage difference between the reference and working electrodes. The measured current and voltage data were then transmitted via Bluetooth to a computer to calculate the NT concentrations with Origin graphing software. When testing the TWEET sensor with artificial plasma, the calculated limit of

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detection (LOD) for DA was found to be 2 nM, with an electrochemical sensitivity is 0.083 uA/uM; the calculated LOD for NE was found to be 1 nM, with a sensitivity of 33.3 uA/uM.

Technology Validation:

The ability of the TWEET system to measure the concentration of DA and NE was initially validated via differential pulse voltammetry (DPV) by exposing the sensor to differing concentrations of both DA (1-2875 micromolar) and NE (0-0.4 micromolar) in 10 mM PBS of pH 7.0, with 1 mM ascorbic and uric acid. With this data, calibration plots for each analyte were constructed (R^2 values of 0.9922 and 0.9978 for DA and NE, respectively) as a basis for correlating to the concentration of the NTs via the measured current from the electrodes. The TWEET sensor was then tested by periodically collecting sweat from 13 human subjects during and after exercise, while also wearing a TWEET prototype arm band. Using HPLC/MS, the concentration of DA and NE was measured and statistically compared to the measured concentration of each NT using the TWEET system via the paired sample t-test. It was found that there was no statistically significant difference between each measurement method (p = 0.6012 â‰¥ 0.05 for DA, and P = 0.2640 â‰¥ 0.05 for NE), indicating that the TWEET system is a viable method to measure the levels of DA and NE in real time.

The selectivity of the TWEET sensor was evaluated via DPV to measure the concentration of DA and NE at ultralow concentrations with real human sweat samples (collected while exercising on a stationary bike). It was found that there were two distinct peaks at ~0.05 V and ~0.39 V, which correspond to the oxidation of NE and DA, respectively. Notably, there were no other distinct peaks in the DPV data, indicating that the TWEET sensor is selective towards detecting only DA and NE, with minimal background noise.

Advantages:

- Real-time monitoring

- LOD of 2 nM for DA, and 1 nM for NE

- Sensitive--0.083 uA/uM for DA and 33.3 uA/uM for NE

- Robust--sensor is still electrochemically stable after 5000 tests

- High selectivity

Applications:

- Personal health monitoring for civil and defense applications

- Health monitoring for patients

- Professional athlete health monitoring

- Occupational safety equipment (e.g. construction worker, factory worker, laboratory technician, transportation driver, pilots, soldiers, etc)

- Mental health monitoring system (measuring levels of NTs in real time to assist with treatment)

- Solutions for early diagnosis, progression monitoring, and treatment evaluation for patients with neurological disorders (e.g., Alzheimer's disease, Parkinson's disease, etc.)

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Intellectual Property:

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