K38 Electrochemical Tools for the Rapid Detection of Opioids and Novel Psychoactive Substances (NPS) With Confirmatory Analysis by Liquid Chromatography/Triple Quadrupole/Mass Spectrometry (LC/QqQ/MS)

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Learning Overview: After attending this presentation, attendees will be able to explain the theory and use of electrochemical techniques as screening tools in forensic science and understand their implications in the testing of NPS.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by advancing toward an electrochemical sensing method that will provide qualitative and quantitative information to enhance workflow in laboratories to speed up screening and analysis, reducing costs and backlogs. The proposed approach will allow on-site testing of unknown substances enabling for non-invasive roadside testing of Driving Under the Influence of Drugs (DUID) suspects and as a rapid on-site detection system on drug seizures.

Due to the growing number of cases involving fentanyl and fentanyl-analogs, opioid abuse poses a significant threat to the United States. Opioid-related overdose deaths have increased over the past several years, leading to a public health emergency declared by the Department of Health and Human Services. NPS have compounded the issue due to having similar or increased potency. NPS are synthetic analogs to known controlled substances designed by making modifications to the core chemical structure in most cases, and include fentanyl-analogs and synthetic cannabinoids, among others. Electrochemistry can provide a rapid, sensitive, and selective screening technique to overcome the limitations faced by other methods in the field. Electrochemistry offers a versatile platform that is sensitive, portable, and low cost, which can be modified to suit a variety of needs and detection requirements.

Cytochrome P450 enzymes represent a class of enzymes suited to work with controlled substances due to their role in the metabolism of the many xenobiotics within the body. Modification relies on the ability to transfer electrons from the working electrode to the heme center of the enzyme to stimulate the enzyme's metabolism of the drug in solution. Additional modification with gold nanoparticles provides a good metal platform that can be used for attachment strategies not possible on carbon, as well as a different electrode surface. Such modification is demonstrated in this study.

Screen-Printed Electrodes (SPEs) allow for a portable and straightforward testing platform due to containing all three needed electrodes within a small area. SPEs are made by depositing alternating layers of conductive material for the electrode surfaces with insulating material and plastic to create a small (~1.5 x 0.5 inches) strip-like testing surface. SPEs are desirable testing platforms due to being low cost and disposable, having high-throughput, and requiring small sample volumes. These SPEs then act as sensors, recording the electrochemical process taking place and can provide qualitative and quantitative data about an analyte in solution. The most common of these SPEs are carbon-based, which provide a large window of potential and possible modifications. These electrodes can be modified with many materials, including enzymes and nanoparticles/nanomaterials. Modifications allow for the activity, sensitivity, and specificity to be controlled for the desired application. Traditional electrochemical testing methodologies also allow for modifications to the electrode surface as well as various types of electrode materials.

Three target drugs were tested: codeine, fentanyl, and PB-22 (a synthetic cannabinoid NPS). Cytochrome P450 enzymes were immobilized on the surface of the electrodes for analysis of codeine. Cyclic voltammetry and chronoamperometry were utilized for the analysis and characterization of the drug in Phosphate-Buffered Saline (PBS). Standard curves from successive additions were generated to determine potential limits of detection. Analysis of fentanyl in PBS via deposited gold nanoparticles on the working electrode was tested to determine its viability as a testing method. Finally, a traditional electrochemical cell approach was utilized with a platinum working electrode for the analysis of PB-22 in acetonitrile containing tetrabutylammonium perchlorate. Additionally, a method using dynamic multiple reaction monitoring with LC/QqQ/MS was developed for confirmatory analysis as part of the development of a pain-management panel containing 28 drugs. This method was designed for use in oral fluid.

Codeine was characterized in PBS buffer, and the limit of detection was found in the low µg/mL levels. Similar ranges of detection were obtained for fentanyl. Detection of fentanyl was possible utilizing only gold nanoparticles on the SPE. Excellent linearity (>0.999) was seen between 3µg/mL and 1µg/mL concentrations tested. The limit of detection of PB-22 was determined to be approximately 208ng/mL with linearity greater than 0.999.

Electrochemistry, NPS, Opioids