Application Note AN-EC-040

芬太尼的化学光(ECL)

Simple system for the detection of fentanyl using electrochemiluminescence

Electrochemiluminescence (ECL) is a highly sensitive analytical technique that combines electrochemical processes with light emission. Due to its versatility, sensitivity, and compatibility with a wide range of luminophores, it is used in clinical analysis, environmental detection, and bioanalytical research.

Fentanyl is a synthetic opioid used for its analgesic and anesthetic properties. It is approximately 100 times more potent than morphine and 50 times more potent than heroin. Despite its medical applications, illicit fentanyl is regularly found on the black market, contributing to a growing global health concern. Most current methods used to detect fentanyl are time-consuming, expensive, or require complex instrumentation. This Application Note presents an ECL method, that offers a fast, accessible, and cost-effective alternative for the detection of fentanyl.

INSTRUMENTATION AND SOFTWARE

ECL experiments were performed using the SpectroECL instrument with either a microspectrometer cell (**Figure 1**) or with a photodiode cell (ECLPHOTODIODCELL) as detector.
Gold screen-printed electrodes (SPEs, 220AT) were used to perform the ECL experiments.
SpectroECL was controlled with the DropView SPELEC software, which allows the collection of the electrochemical and emitted light signal simultaneously. Furthermore, the software includes tools for data treatment and analysis. **Table 1** lists all hardware and software used for this study.

Figure 1. SpectroECL instrument and microspectrometer cell.

Table 1. Hardware and software equipment overview.

Equipment	Article number
Instrument	SPECTROECL
Cell	ECLPHOTODIODCELL
Gold SPE	220AT
Connection cable for SPEs	CAST
Software	DropView SPELEC

ECL DETECTION OF FENTANYL DRUG

Fentanyl CII (USP Reference standard), tris(2,2'-bipyridyl)dichlororuthenium(II) hexahydrate (Rubpy, Sigma-Aldrich), sodium chloride (Sigma-Aldrich), potassium chloride (Sigma-Aldrich), sodium phosphate dibasic (Sigma-Aldrich), and potassium phosphate monobasic (Sigma-Aldrich) were used as received. All chemicals were analytical grade. Aqueous solutions were prepared using ultrapure water (Direct-QTM 5 system, Millipore).
The ECL system consists of Rubpy as luminophore and fentanyl as co-reactant in 0.1 mol/L PBS aqueous buffer (pH 6). The electrochemical oxidation of Rubpy starts a sequence of chemical reactions that produces light emission at 620 nm. This emission depends on the fentanyl concentration, allowing detection of this compound.

The initial evaluation and characterization of Rubpy emission in the presence of this opioid were performed using the microspectrometer cell. To optimize the ECL signal, the potential was scanned from 0.40 V to 1.20 V using a gold SPE and PBS pH 6 buffer solution. The microspectrometer detector collects visible spectra, providing information that is useful for the understanding of the system under study. **Figure 2** confirms the Rubpy emission at 620 nm due to the presence of fentanyl as co-reactant. The blank experiment without fentanyl does not show any ECL band.

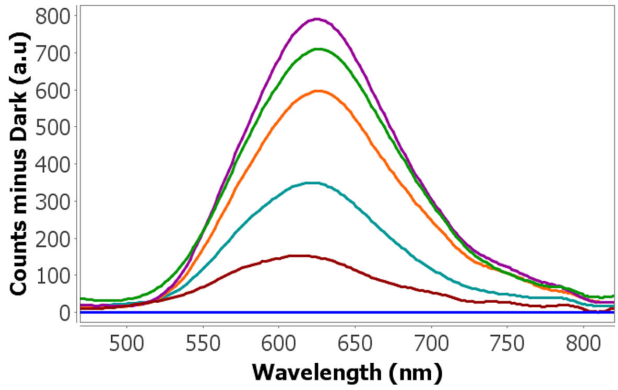

Figure 2. Characteristic ECL emission of Rubpy observed while the potential was scanned from 0.40 V to 1.20 V for 0.0025 mol/L, Rubpy, 0.0001 mol/L fentanyl in 0.1 mol/L PBS (pH 6) solution.

Once the emission from Rubpy was confirmed, the SpectroECL and photodiode cell were used to analyze lower concentrations of fentanyl. The same electrochemical conditions as in the experiment with the microspectrometer cell were used. The signal obtained with the photodiode cell consists of the total ECL emission (green line **Figure 3**), instead of emission spectra across the visible range. Simultaneously, the electrochemical signal was recorded (blue line **Figure 3**). Although this detector does not differentiate wavelengths, it provides high sensitivity. ECL increases at potentials higher than 0.85 V, reaching the maximum around 1.00 V.

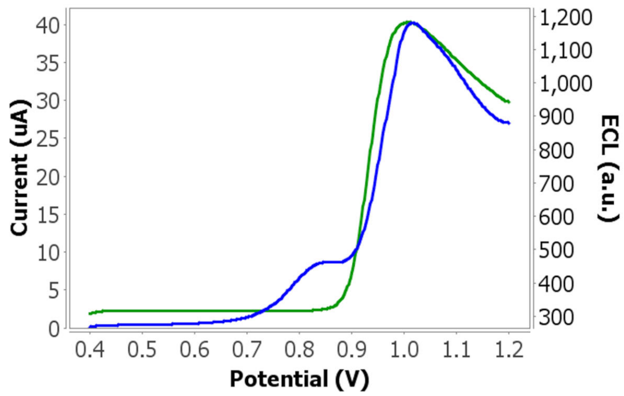

Figure 3. Linear sweep voltammetry (blue line) and Rubpy ECL emission (green line) of 0.0025 mol/L Rubpy and 0.001 mmol/L fentanyl in 0.1 mol/L PBS (pH 6) solution.

Metrohm

The height of the ECL signal at 1.00 V was measured, and a calibration curve from 0001 mmol/L to 0.01 mmol/L fentanyl was plotted (**Figure 4**). The high correlation coefficient (R^2 = 0.998) confirms the good linearity and sensitivity of the ECL method for detecting fentanyl in this concentration range.

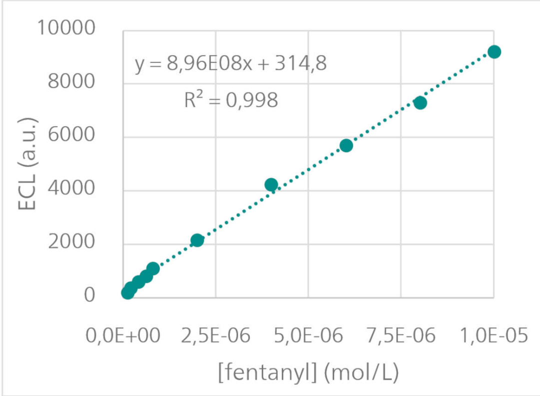

Figure 4. Calibration curve of ECL intensity at 1.00 V for different concentrations of fentanyl and 0.0025 mol/L Rubpy in 0.1 mol/L PBS (pH 6) solution.

CONCLUSION

ECL is a powerful technique that provides reliable results in the study of a variety of luminophores. The combination of the microspectrometer cell for the ECL emission spectra and the photodiode detector for improved sensitivity by measuring total ECL intensity, enables a clear understanding of the analyzed system and supports quantification of the target analyte.

As proof of concept, this Application Note demonstrates the detection of fentanyl based on the characteristic ECL emission of Rubpy in presence of this compound. As the ECL signal depends on the concentration of fentanyl in solution, the obtained results open new paths for the development of ECL sensors for opioids detection.

CONTACT

Metrohm AG
Ionenstrasse
9100 Herisau

info@metrohm.com

SpectroECL 将一个双恒位/恒流和一个微型光集成在一个用于网印刷的新池中。小型化的便携式器非常合行致化学光(ECL)量。

用于网印刷的池,可行化学光量。 ABS 池包含一个前置放大器的硅光二管,其光范 340 - 1100 nm,峰敏度波 960 nm。
池与 μStat ECL 或 μStat SpectroECL 化学光器配合使用。