Bipolar Electrochemiluminescence with Laminated Stainless Steel Foil Electrode for Detection of Hydrogen Peroxide

Nantita Nokhudtima[1] , Apisith Phujeenaphun[1] and Tinakorn Kanyanee[1*]

[1]Department of Chemistry, Faculty of Science, Chiang Mai University, Thailand

[*]Corresponding Author's Email: tkanyanee2@gmail.com

Abstract

This study presents the development and application of laminated stainless steel foil as a bipolar electrode (BPE) for bipolar electrochemiluminescence (bECL), with a smartphone used as the optical signal detection device. The electrode was fabricated using a simple and low-cost preparation process The developed bECL system was applied to the luminol/H_2O_2 reaction and demonstrated a linear relationship between bipolar electrochemiluminescence (bECL) intensity and hydrogen peroxide concentration over the range of 2–200 µM, with a limit of detection (LOD) of 1.35 µM. The proposed system emphasizes low cost, operational simplicity, and suitability for field applications, as it utilizes an inexpensive direct current power supply instead of a conventional potentiostat.

Introduction

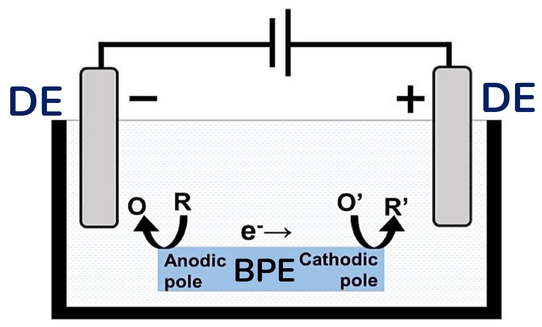


Figure 1. Schematic diagram illustrating the principle of bipolar electrochemistry (BPE).

Bipolar Electrochemiluminescence (bECL) is an electrochemical technique that produces light via redox reactions at a bipolar electrode under an applied electric field, offering high sensitivity and low background signal for H_2O_2 detection. The performance of bECL can be improved using porous-gold laminated stainless steel electrodes, which provide good electrical conductivity, mechanical strength, and low cost. The porous gold structure increases the electroactive surface area and enhances electron transfer, promoting reactions with H_2O_2 As a result, detection sensitivity is improved, making this electrode suitable for H_2O_2 detection using bECL systems.

Experimental

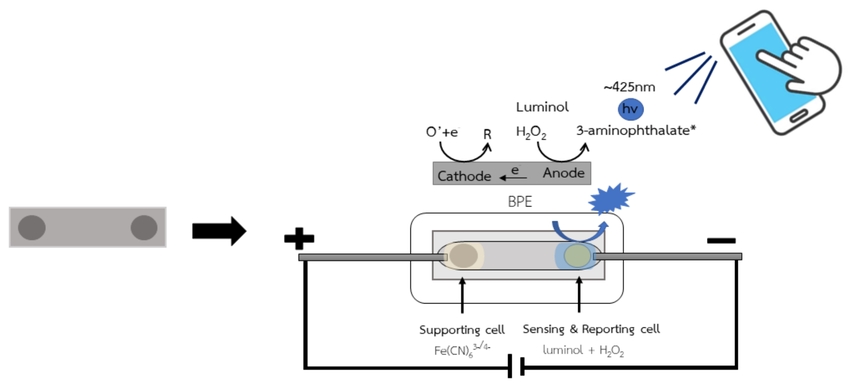


Figure 2. schematic diagram of bECL measurement via smartphone based on porous gold-laminated stainless steel foil electrode (pAu-SST).

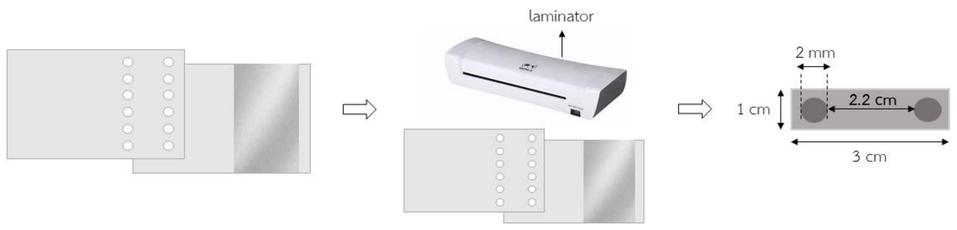


Figure 3. Fabrication of porous-gold laminated stainless steel foil electrode (pAu-SST).

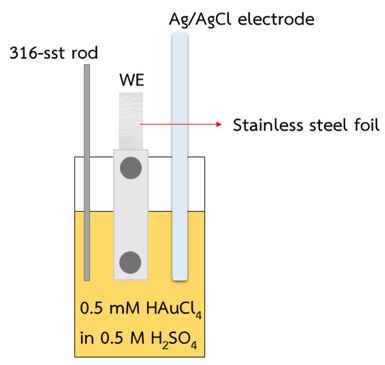


Figure 4. electrodeposition setup for fabrication of pAu-SST.

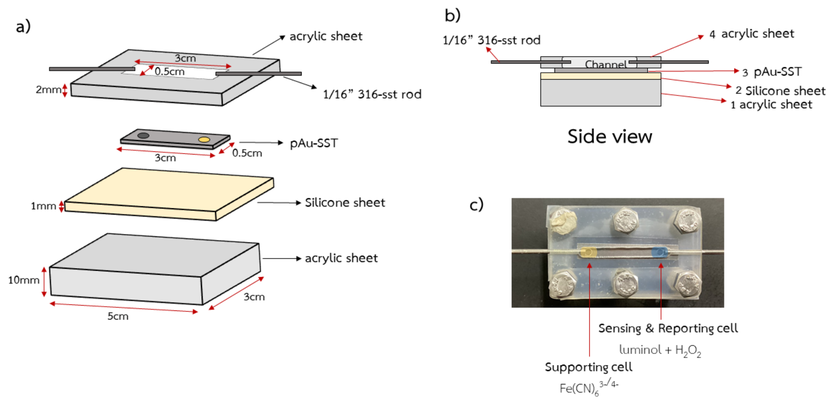


Figure 5. Fabrication of bECL cell, **a)** bECL cell fabrication, **b)** side view of bECL cell, and **c)** The photograph of bECL cell.

Results

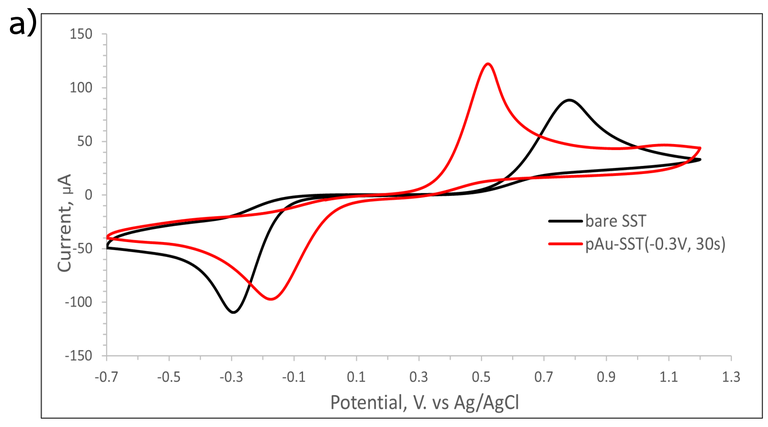


Figure 6. Characteristic of pAu-SST, **a)** Cyclic voltammogram of Bare SST and pAu-SST (in 10 mmol L^{-1} $Fe(CN)_6^{3-/4-}$, RE: Ag/AgCl electrode, AE: 316-stainless steel rod, potential range: 0, 1.2, -0.7, scan rate: 100 $mV.s^{-1}$), SEM image of **b)** Bare SST and **c)** pAu-SST (-0.3V)

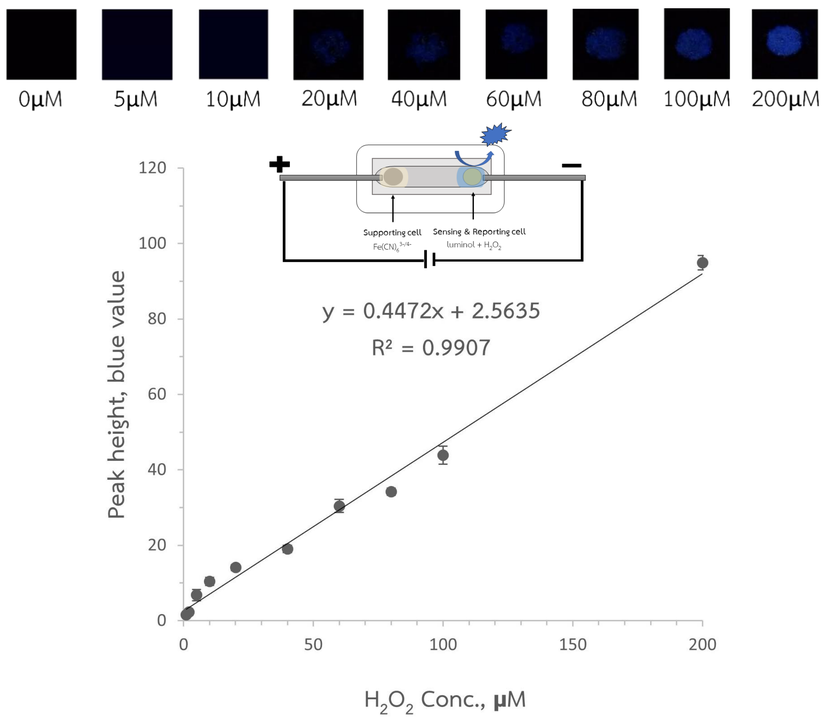


Figure 7. Calibration graph of H_2O_2 concentration on pAu-SST as BPE for luminol/H_2O_2 reaction. (5 mmol L^{-1} luminol in carbonate buffer pH10.00, 2-200 µmol L^{-1} H_2O_2)

Conclusions

- A low-cost porous gold-laminated stainless steel foil electrode (pAu-SST) was developed as a bipolar electrode (BPE) for the bipolar electrochemiluminescence (bECL) system, with signal detection performed using a smartphone.
- The porous gold structure increased the electroactive surface area and reduced the potential required to drive the electrochemical reaction.
- The system demonstrated effective detection of the luminol/H_2O_2 reaction, with a linear range of 2–200 µM and a limit of detection (LOD) of 1.35 µM.
- Owing to its low cost, simple fabrication, and portability, this platform shows strong potential for the development of portable ECL-based biosensors.

Acknowledgements

- Fundamental Fund (FF 2025)
- CMU Mid-Career Research Fellowship program
- Dr. Bruno Werdelmann Foundation
- Department of Chemistry, Faculty of Science, Chiang Mai University, Thailand

Reference

[1] Phujeenaphun, A., Tinala, C., Jakmunee, J., Xu, G., & Kanyanee, T. (2026). Talanta, 298, 128992.