Zensor R&D

2.2 Screen printed silver electrode

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Silver has been reported to be either a working electrode to detect halide ion in the field of biomedical, food, environment, etc. or being a reference electrode. As a stable reference electrode, it must be treated to the form of silver chloride to provide a constant reference potential. Alternatively, it is sometimes treated as the silver oxide to be the pseudo reference electrode. The value of measured potential is compared with standard potential as shown the Figure 1 which is published by Zen's group. The potential of Ag/Ag_xO is about -0.153 V respected to the SHE, and the potential of Ag/AgCl is around 0.197 V to SHE. (1)

Figure 1. The value of measured potential is compared with standard potential.

(1)Mei-Hsin Chiu, Wan-Ling Cheng, Govindan Muthuraman, Cheng-Teng Hsu, Hsieh-Hsun Chung, Jyh-Myng Zen, Biosensors and Bioelectronics 24 (2009) 3008–3013

2.2.1 Halide ion detection at screen printed silver electrode

On the other hand, screen printed silver as a working electrode, analyzed the halide ions in aqueous solutions has been reported. The disposable silver electrodes is fabricated by screen printed silver ink on the surface of polypropylene, in which composed of silver working electrode, silver counter electrode and silver/silver oxide reference electrode to be a electrochemical detector as shown in the Figure 2. (1)

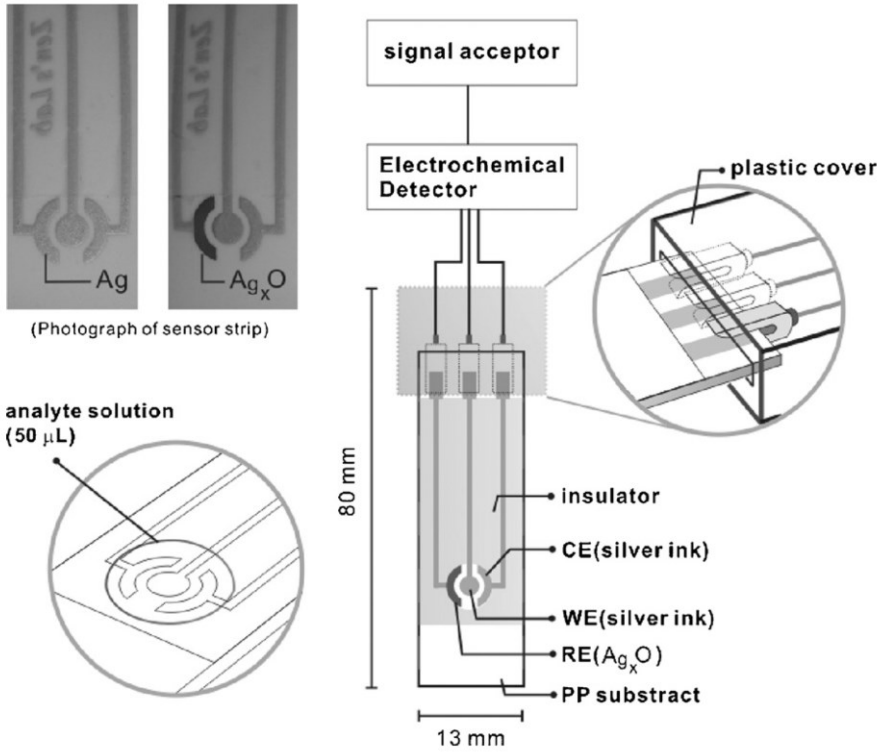

Figure 2. Schematic representation of the set-up for single drop analysis of halide in aqueous solutions at the SP-AgES.

(1)Mei-Hsin Chiu, Wan-Ling Cheng, Govindan Muthuraman, Cheng-Teng Hsu, Hsieh-Hsun Chung, Jyh-Myng Zen, Biosensors and Bioelectronics 24 (2009) 3008–3013

2.2.1 Halide ion detection at screen printed silver electrode

Typical silver voltammogram and its detection of halide ion is illustrated that the well separated oxidation potential for Cl^-, Br^- and I^- was obtained by a single drop of analyte as shown in the Figure 3. In addition, Figure 4 demonstrates that the simultaneous detection of mixed halide ions solution of Cl^-, Br^- and I^- from low concentration of 100 µM to high concentration of 10 mM. (1)

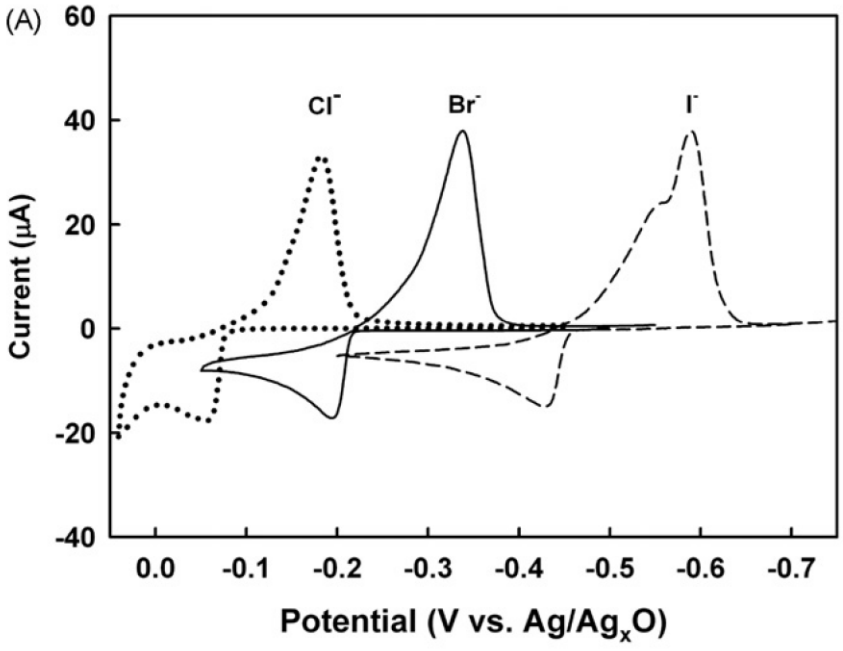

Figure 3. Cyclic voltammograms of halide ions (500µM each)

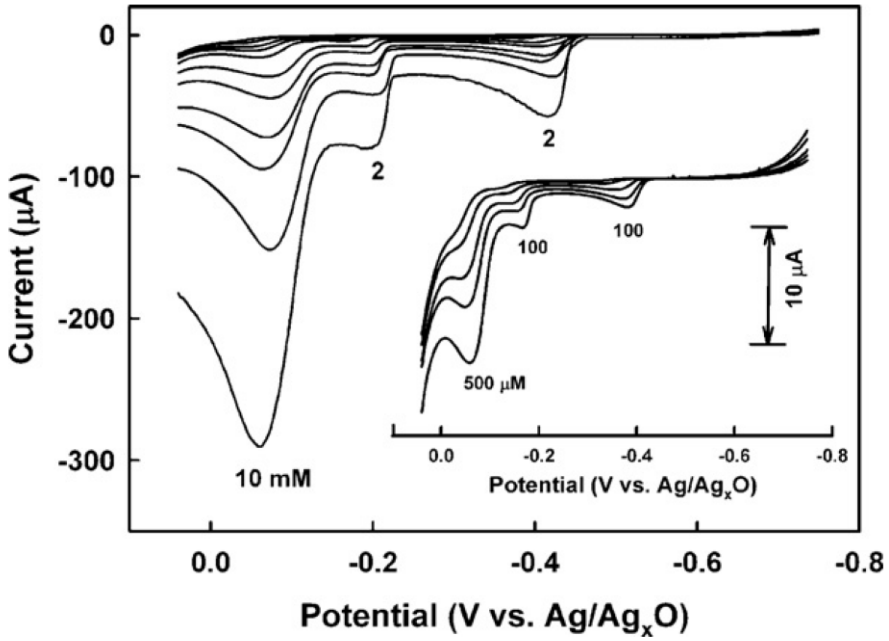

Figure 4. Simultaneous determination of halide ions at the SP-AgES by linear scan voltammetry in 0.1 M, pH 6 PBS.

(1)Mei-Hsin Chiu, Wan-Ling Cheng, Govindan Muthuraman, Cheng-Teng Hsu, Hsieh-Hsun Chung, Jyh-Myng Zen, Biosensors and Bioelectronics 24 (2009) 3008–3013

2.2.2 Determination of Pb^{2+} at screen-printed silver electrode

Moreover, screen-printed silver electrodes (AgSPEs), a powerful tool without chemical modification, has been employed for the measurement of trace levels of Pb^{2+}. Professor Zen reported that the determining Pb^{2+} at trace levels using the reversible underpotential deposition peak (UPD-Pb) was examined by square-wave anodic stripping voltammetry, and resulting sensitivity, linearity, and detection limit are 0.355A/ppb, 5–80 ppb (r = 0.9992), and 0.46 ppb (S/N = 3), respectively. (see Figure 5,6) The practical applications were demonstrated to measure trace Pb^{2+} in natural waters. (1)

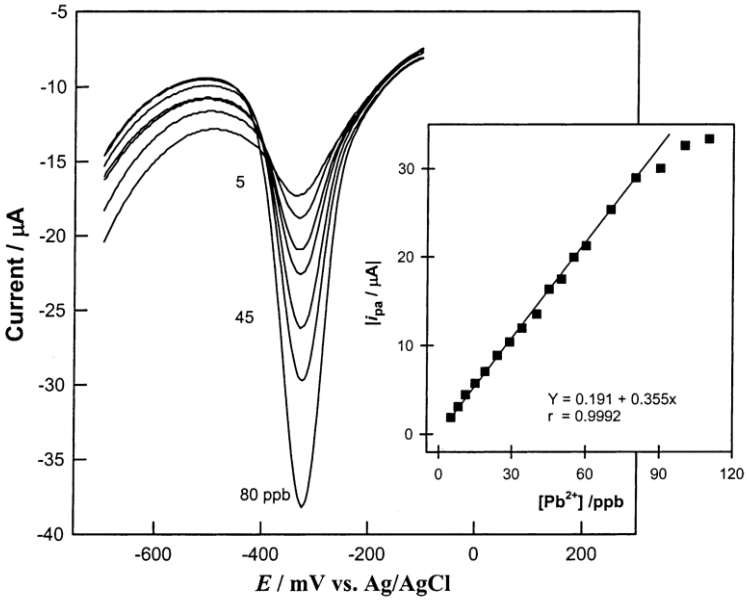

Figure 5. SWV responses for the increasing concentration of Pb^{2+} under optimized experimental conditions.

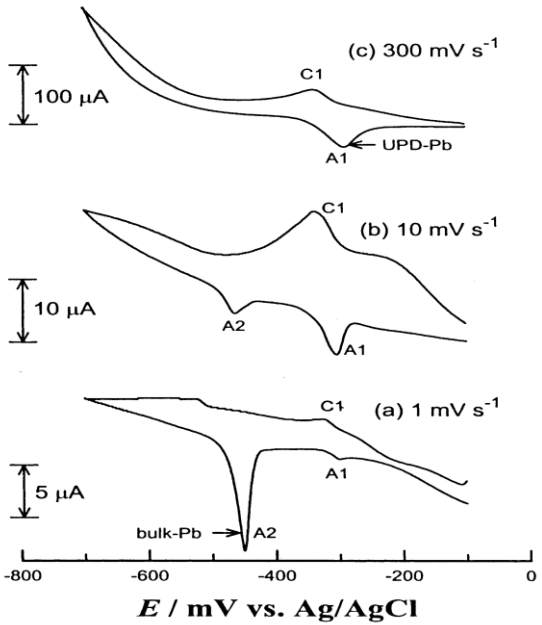

Figure 6. CV responses of 96.5 µM Pb^{2+} in pH 3 KNO_3/HNO_3 solution at the AgSPE under various scan rates.

Reference
(1)Jyh-Myng Zen, Chih-Chio Yang, Annamalai Senthil Kumar, Analytica Chimica Acta 464 (2002) 229–235

2.2.3 Selective cosmetic mercury analysis using a screen printed silver electrode with potassium iodide solution

Professor Shih demonstrated that a method for the determination of trace mercury (Hg) by linear scan voltammetry using screen printed silver electrode (AgSPE) in the presence of potassium iodide. The iodide oxidation occurred at AgSPE was found to be systematically decreased as a signal of inhibitory anodic current with increasing the Hg concentrations and resulting a powerful cosmetic mercury sensor. (see Figure 7) (1)

Electrochemical oxidation:

$$2I^-_{bulk} \rightarrow I_2 + 2e^-$$

Chemical (inhibitory step):

$$Hg^{2+} + 3I^-_{bulk} + \tfrac{1}{2}\, I_2 \rightarrow [HgI_4]^-$$

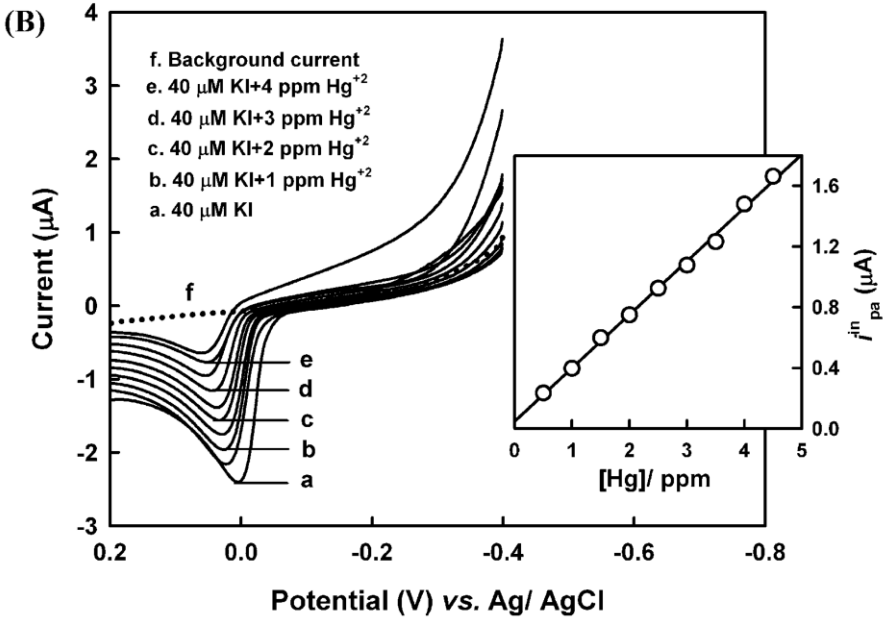

Figure 7. Forward scan LSV response of AgSPE with increasing Hg concentration

Reference

(1)Mei-Hsin Chiu, Jyh-Myng Zen, Annamalai Senthil Kumar, Dhananjayan Vasu, Ying Shih, Electroanalysis 20, 2008, No. 20, 2265 – 2270

2.2.4 Cosmetic hydrogen peroxide detection using nano bismuth species deposited built-in three-in-one screen printed silver electrode

As the Professor Shih and Professor Zen published, the nano-bismuth modified screen printed silver electrode (SPAgE-Bi^{nano}) has been developed for electrochemical sensing of cosmetic hydrogen peroxide (H_2O_2) from 100 µM to 5mM in neutral medium. The screen printed silver three electrode was fabricated with three silver electrode system as shown in Figure 8. And the deposited 50 nm Bi particles was proved with SEM technique. (see Figure 9) The electro-catalytic H_2O_2 reduction reaction is sensitively detected at SPAgE-Bi^{nano} as shown in Figure 10. (1)

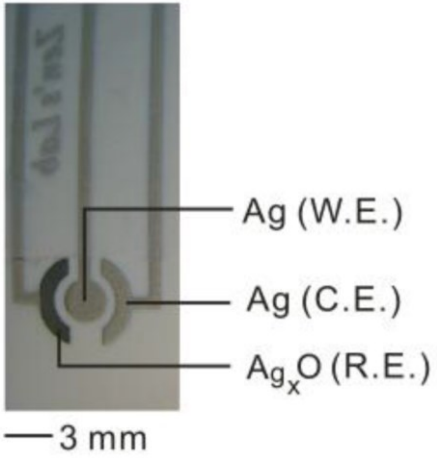

Figure 8. Picture of SPAgE

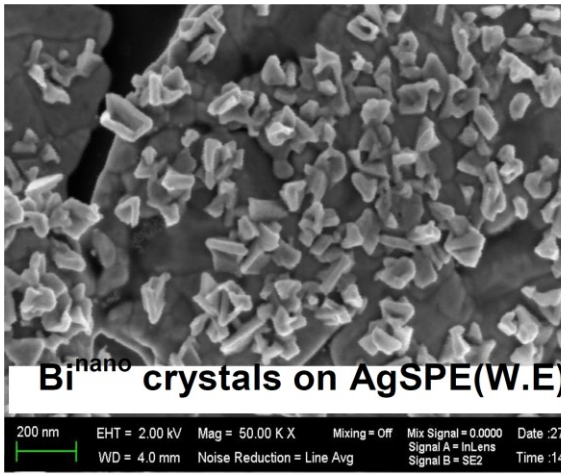

Figure 9. SEM picture of SPAgE-Bi^{nano}

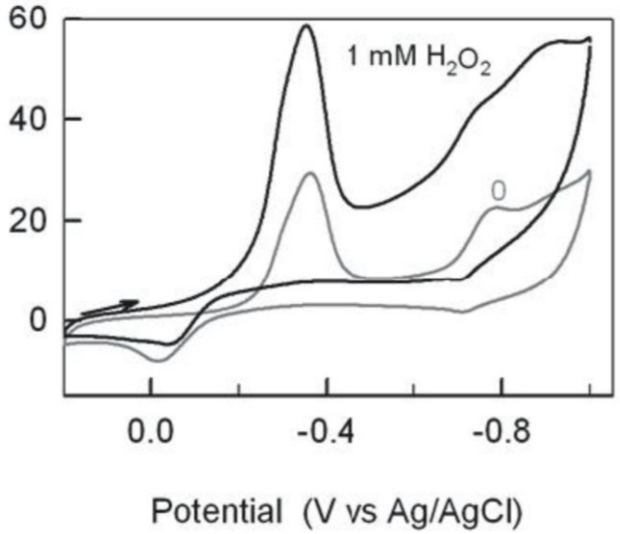

Figure 10. Cyclicvoltammogram of SPAgE-Bi^{nano} toward reduction of H_2O_2

Reference
(1)Mei-Hsin Chiu, Annamalai Senthil Kumar, Sundaram Sornambikai, Pei-Yen Chen, Ying Shih, and Jyh-Myng Zen, Int. J. Electrochem. Sci., 6 **(2011)** 2352 - 2365