

科技部補助專題研究計畫成果報告 期末報告

含硒與其衍生物之化妝品與藥品測定方法之研究

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執行單位：嘉藥學校財團法人嘉南藥理大學醫藥化學系

計畫主持人：王來好

計畫參與人員：碩士級-專任助理人員：劉彩芸

中華民國 105 年 10 月 09 日

中文摘要：本研究設計新電化學技術，製配5種硫醇(thiol)化合物薄膜 (2, 4-thiazolidinedione, 2-mercapto-5-thiazoline, 2-mercaptothiazoline, L-cysteine, thioglycolic acid)，修飾金電極當工作電極。裝入流動式電解槽 (flow cell) 中，當作檢測器並連線高效率液相層析儀，測定甲硒胺酸 (L-selenomethionine) 和甲基硒代半胱胺酸 (Se-methylseleno-L-cysteine) 之含量。二種有機硒的電化學氧化效果在硫醇(thiol)修飾金電極測定之靈敏度皆比未修飾金電極為高。利用DC模式，合適的實驗參數測定，線性濃度從10至1600 ng mL⁻¹。二種有機硒的偵測極限低於10 ng mL⁻¹。此方法可以適用於定量測定市售含有硒補充產品之甲硒胺酸和甲基硒代半胱胺酸。比較高效率液相層析法連線伏安檢測器和紫外線檢測之結果是一致。

中文關鍵詞：硫醇化合物修飾金電極；甲硒胺酸；甲基硒代半胱胺酸

英文摘要：A flow-electrolytical cell containing a thio-compounds (2, 4-thiazolidinedione, 2-mercapto-5-thiazoline, 2-mercaptothiazoline, L-cysteine, thioglycolic acid) modified gold electrodes has been designed and characterized for use in a voltammetric detector for detecting L-selenomethionine and Se-methylseleno-L-cysteine using high-performance liquid chromatography. Both L-selenomethionine and Se-methylseleno-L-cysteine are more efficiently electrochemical oxidized on a thio/ Au than a bare gold electrode. For the DC mode, and measurements with suitable experimental parameters, a linear concentration from 10 to 1600 ng mL⁻¹ was found. The limit of quantification for L-selenomethionine and Se-methylseleno-L-cysteine were below 10 ng mL⁻¹. The method can be applied to the quantitatively determining L-selenomethionine and Se-methylseleno-L-cysteine in commercial containing selenium supplement products. Findings using high-performance liquid chromatography with a flow-through voltammetric detector and ultraviolet detector are comparable.

英文關鍵詞：Thiol-compounds modified gold electrodes, L-selenomethionine, Se-methylseleno-L-cysteine.

科技部補助專題研究計畫成果報告

(期中進度報告/期末報告)

(計畫名稱)

含硒與其衍生物之化妝品與藥品測定方法之研究

計畫類別：個別型計畫 整合型計畫

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計畫參與人員：

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中 華 民 國 105 年 10 月 5 日

Electrochemical oxidation of L-selenomethionine and Se-methylseleno-L-cysteine at a thiol-compounds modified gold electrodes Its Application in a flow—through voltammetric sensor

利用硫醇薄膜修飾金電極之流動式伏安感測器測定市售藥品中甲硒胺酸和甲基硒代半胱胺酸

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中文摘要

本研究設計新電化學技術，製配 5 種硫醇(thiol)化合物薄膜 (2, 4-thiazolidinedione, 2-mercapto-5-thiazoline, 2-mercaptothiazoline, L-cysteine, thioglycolic acid)，修飾金電極當工作電極。裝入流動式電解槽 (flow cell) 中，當作檢測器並連線高效率液相層析儀，測定甲硒胺酸 (L-selenomethionine)和甲基硒代半胱胺酸 (Se-methylseleno-L-cysteine)之含量。二種有機硒的電化學氧化效果在硫醇(thiol)修飾金電極測定之靈敏度皆比未修飾金電極為高。利用 DC 模式，合適的實驗參數測定，線性濃度從 10 至 1600 ng mL⁻¹。二種有機硒的偵測極限低於 10 ng mL⁻¹。此方法可以適用於定量測定市售含有硒補充產品之甲硒胺酸和甲基硒代半胱胺酸。比較高效率液相層析法連線伏安檢測

器和紫外線檢測之結果是一致。

關鍵詞：硫醇化合物修飾金電極; 甲硒胺酸; 甲基硒代半胱胺酸。

英文摘要

A flow-electrolytical cell containing a thio-compounds (2, 4-thiazolidinedione, 2-mercapto-5-thiazoline, 2-mercaptothiazoline, L-cysteine, thioglycolic acid) modified gold electrodes has been designed and characterized for use in a voltammetric detector for detecting L-selenomethionine and Se-methylseleno-L-cysteine using high-performance liquid

chromatography. Both L-selenomethionine and Se-methylseleno-L-cysteine are more efficiently electrochemically oxidized on a thio/ Au than a bare gold electrode. For the DC mode, and measurements with suitable experimental parameters, a linear concentration from 10 to 1600 ng mL⁻¹ was found. The limit of quantification for L-selenomethionine and Se-methylseleno-L-cysteine were below 10 ng mL⁻¹. The method can be applied to the quantitative determination of L-selenomethionine and Se-methylseleno-L-cysteine in commercial containing selenium supplement products. Findings using high-performance liquid chromatography with a flow-through voltammetric detector and ultraviolet detector are comparable.

Keywords: Thiol-compounds modified gold electrodes, L-selenomethionine, Se-methylseleno-L-cysteine.

内容
前言

Selenium (Se) -based complementary medicine which confers protection

against hyperandrogenism induced polycystic ovary [1]. Bacteriostasis experiment in vitro of Se-enriched herbal medicine compound prescription to Escherichia coli and Salmonella [2-3]. Therefore, it is used to prepare high-energy composite peptide selenoprotein nutrient solution [4]. Selenium is an essential component of several antioxidant enzymes in animal taxa, and exposure to too much or too little Se can have negative impacts [5]. It has been reported that the concentrations for toxicity, bioavailability, and reactivity of Se depend on its chemical forms and concentration. Medicinal plants enriched with anticarcinogenic Se compounds can be used to improve public health. Se in plants predominantly exists in organic forms, such as selenoamino acids and trace quantity of inorganic Se species. Hence, accurate and precise analytical methodologies for the determination of Se are required for obtaining correct chemical forms and concentration [6-8].

研究目的

Several methods for determination of Se

have been developed for many years. These include fluorescence spectrophotometry [9-10], microscopic identification [11], atomic absorption spectrometry [12-13], inductively coupled plasma atomic emission spectroscopy (ICP-AES) [14-15], chromatographic separation coupled to inductively coupled plasma mass spectrometry HPLC-ICP-MS [16-20], electrochemical techniques [21-31]. Generally, the analytical techniques employed for Se determination are HPLC-ICP-MS. Due to the low limit of detection, selectivity, and sensitivity is widely used for the determination of Se in different matrices. Voltammetric techniques are inexpensive, excellent sensitive and selective, and have been mainly used to speciation analysis and mechanism studying. The electrochemical behavior of selenocystine (SeCyst) has previously been studied on Au, Ag, and silver nitrate-modified carbon paste electrodes [21]. Electrochemical oxidation of selenocystine and selenomethionine on gold electrode was investigated [22], and gold film modified glassy carbon

electrode [23]. Since the mainstream development of gold-alkanethiol self-assembled monolayers (SAMs) in the early 1980s, they have found widespread utility in the fabrication of chemical and biological sensors [24-31]. Among these, the most inexpensive and simplest way to synthesize thin films of variety of compounds based on various SAMs on gold surfaces. However, no research has yet been conducted, to our knowledge, on the electrodeposited thio-therocycles groups (2, 4-thiazolidinedione, 2-mercapto-5-thiazoline, 2-mercaptothiazoline) and alkane thiol groups (L-cysteine, thioglycolic acid) thin film on gold electrode. L-selenomethionine and Se-methylseleno-L-cysteine appeared to be adsorbed on Au surfaces mainly via the strong Au-S binding that developed following Se-Se breakage gold selenide complex thin film. In current investigation, we report a novel concept of sensing L-selenomethionine and Se-methylseleno-L-cysteine the self-assembled monolayer (SAM)-covered gold electrode by a

selective chemical reaction with thiol groups as a sensor; and coupled with HPLC. Electrochemical flow cell devices were designed which were used for studying L-selenomethionine and Se-methylseleno-L-cysteine flow through gold and modified gold electrode electrochemical processes. The optimum experimental conditions for the determination of L-selenomethionine and Se-methylseleno-L-cysteine in pharmaceutical products are described in this paper.

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研究方法

2.1. Apparatus and Materials

All electrochemical measurements were performed with a potentiostat-galvanostat (SP-150; Bio-Logic SAS, 1 rue de l'Europe 38640 - CLAIX - FRANCE) with a conventional three-electrode configuration with gold and thio compound modified gold as working electrode. Potentials were measured versus the Ag/AgCl electrode (RE-1; Bioanalytical Systems, West Lafayette, IN, USA), and a platinum wire was used as the auxiliary electrode. A high performance liquid chromatography (HPLC) system (LC-10 ADvp; Shimadzu, Kyoto, Japan) containing a Rheodine 7125 injection valve with a 20 mL sample

loop was coupled to an amperometric detector (Decade SDC; Antec Leyden B.V., Zoeterwoude, Netherlands). The flow cell was designed with the following electrodes: an Ag/AgCl/0.1 M KCl reference electrode (Bioanalytical Systems), a platinum auxiliary electrode, and a gold or thiol compound modified gold electrode (length: 8 cm; i.d., 3 mm) as the working electrode for detecting L-selenomethionine and Se-methylseleno-L-cysteine. The compound as following: L-selenomethionine, Se-methylseleno-L-cysteine, 2-mercapto-5-thiazoline purchased from TCI (Tokyo, Japan), 2,4-thiazolidinedione was purchased from Acros Organics (Geel, Belgium); 2-mercaptothiazoline purchased from Alfa Aesar (Ward Hill, MA, USA), L-cysteine purchased from Sigma (St. Louis, MO, USA) and thioglycolic acid purchased from E. Merck Chemical Co., (Darmstadt, Germany). The selenium supplement drugs investigated were purchased from abroad. All other reagents were of analytical grade.

2.2. Determining L-selenomethionine by CV

Cyclic voltammetry (CV) was performed in a phosphate buffer (pH 2.23- 6.57), acetate buffer (pH 4.18), Britton and Robison buffer (pH 2.46 -10.45), and lithium perchlorate (LiClO₄) solutions as supporting electrolytes on a gold electrode. CV potentials ranged from -0.4 V to +1.5 V at a scan rate of 25 mV s⁻¹. The CV data were performed using SP-150, Bio-Logic SAS and EC-Lab® softwares. Stock solution of standard was prepared by dissolving the appropriate amount of L-selenomethionine in methanol.

2.3 Preparation modified of the thiol /Au electrodes

The gold wire electrodes were cleaned then was placed in the tube containing thiol compound solution, deoxygenated by purging with nitrogen for 5 min. The modified of thiol /Au was electrolytically plated with thiol compound (i. e., 2-mercapto-5-thiazoline,

2-mercaptothiazoline, L-cysteine, thioglycolic acid, 2, 4-thiazolidinedione) from 10 mL of 0.1 M acetate buffer (pH 4.23) that was 0.01 to 1.6 mM thiol solution, respectively, and the potential was cycled between 0.0 V and 1.5 V (versus a Ag/AgCl reference electrode) with a scan rate of 25 mV s⁻¹ until the cyclic voltammograms showed no further change.

2.4. Construction of a voltammetric sensor for LC

The flow cell was designed with the following electrodes: an Ag/AgCl/0.1 M KCl reference electrode, a stainless steel auxiliary electrode, and a modified thiol /Au (length 8 cm, i.d. 0.3 mm) as working electrode for detecting L-selenomethionine and Se-methylseleno-L-cysteine. The amperometric detection was achieved in a home-made flow through cell prepared in our laboratory as previously described [32]. A flow-through electrolysis cell was used for DC-mode amperometric detection. Reversed-phase HPLC was done on a LiChroCART[®] (250 mm × 4.6

mm) column eluted with methanol and water (10:90 v/v) containing 1.0 mM of KH₂PO₄ (pH 3.89) as the mobile phase, at a flow rate of 1.0 mL min⁻¹. It was examined using an ultraviolet (UV) detector set at 248 nm. The electrochemical detector was operated at +0.6 V to 1.3 V for gold and modified of the thiol /Au electrodes.

2.5. Application to commercial selenium supplement drugs

A set of standard solutions was produced by diluting aliquots of the stock solutions with methanol to 10 mL in calibrated flasks. Taking into account the L-selenomethionine or Se-methylseleno-L-cysteine content of the selenium supplement drugs samples (approx. 0.008-0.02 g) the latter were weighed accurately in a 55 mL Polyflouroalkoxy bottle diluted to about 10 mL methanol:water (1:1,v/v) and put in microwave (CEM corporation MARS 6 system, USA), dissolved and centrifuged. The supernatant was transferred into a 10 mL calibrated flasks. An aliquot of the solution was

filtered through a 0.45 μm membrane filter prior to HPLC analysis. A chromatograph was obtained using 20 mL of the prepared standard solution under the operating conditions described above.

結果與討論

3.1 Voltammetric behavior of L-selenomethionine on Au electrode

The cyclic voltammograms of L-selenomethionine on gold and modified of the thiol /Au electrodes were illustrated in Fig. 1. Anodic peak potential and current in 0.1M acetate buffer (pH 4.23) were (0.768 V, 6.39 μA), (1.21 V, 8.86 μA), (1.12 V, 12.4 μA), (0.89 V, 4.76 μA), (1.01 V, 7.03 μA) and (1.03 V, 5.03 μA) for L-selenomethionine, 2-mercaptothiazoline, 2-mercapto-5-thiazolidone, L-cysteine, thioglycolic acid and 2,4-thiazolidinedione, respectively. The effect of pH on the electrochemical response of L-selenomethionine was investigated (Fig. 2A and B). On the basis of L-selenomethionine pKa values in acid

(pK 2.15) and alkaline (pK 8.94) different species may be present in aqueous solutions [22]. From Fig. 2 can be seen, pH 2.5 and 4.2 the peak current are more high and pH 4.2 peak potential the lowest within the acidic range. Since acidic solution suitable for HPLC column, all the following experiments were carried out in pH 4.2.

3.2 Optimum conditions for a flow-through voltammetric detector

Various ratios of methanol-water containing 0.1 mM phosphate buffer (pH 3.5- 4.2) were prepared. After various studies of the retention behavior of L-selenomethionine (retention time 3.62) and Se-methylseleno-L-cysteine (retention time 2.77), baseline separation was achieved. methanol-water (10:90, v/v) containing phosphate buffer (pH 3.92) was found to be the best eluent for a good sensitivity, higher than that observed with other eluents, therefore phosphate buffered solution was chosen for the determination of L-selenomethionine and Se-methylseleno-L-cysteine. To compare the electroanalytical utility of

thiol /Au electrodes, we measured the LC-ECD of the L-selenomethionine and Se-methylseleno-L-cysteine on thiol /Au electrodes and bare Au electrode in methanol-water (10:90, v /v), respectively. From Fig. 3 and 4 can be seen, the peak height of L-selenomethionine and Se-methylseleno-L-cysteine at thiol/Au electrodes are higher than that bare Au electrode, and the catalytic effect of thioglycolic acid (TGA) is most than the other thiol/Au electrodes. Therefore, we used the TGA/Au electrode to determine L-selenomethionine and Se-methylseleno-L-cysteine in a commercial selenium supplement drugs. The voltammetric detector was operated at + 1.2 V. Using the injection valve, 20 μ L of the prepared standard solutions were chromatographed under the operating conditions described above. The lower limit of quantitative detection in our method was approximately 0.16 and 0.07 ng for L-selenomethionine and Se-methylseleno-L-cysteine, respectively. The calibration graph plots obtained by plotting the peak area against the concentration of

L-selenomethionine and Se-methylseleno-L-cysteine show good linearity over the range 10 to 1600 ng mL⁻¹ and 50 to 1600 ng mL⁻¹, respectively. The regression equations were $y = 157 x + 4.5$ (R = 0.9987), and $y = 332 x - 7.8$ (R = 0.9996), for L-selenomethionine and Se-methylseleno-L-cysteine, respectively. Chromatograms obtained using LC-ECD and LC-UV (wavelengths at 248 nm) of L-selenomethionine and Se-methylseleno-L-cysteine standard solutions are shown in (Fig. 5A and 5B), respectively.

3.3. Accuracy and precision

In order to test the applicability of the developed TGA/Au electrode, a commercial selenium supplement drugs was analyzed using the standard addition method. Recovery tests are carried out on drug products to evaluate the reproducibility and accuracy of the proposed LC-ECD and LC-UV methods. The sample is diluted with methanol and water, and the samples are spiked with different concentrations of

L-selenomethionine and Se-methylseleno-L-cysteine. The recoveries range from 97% to 104%. Table 1 shows the results (with an average of three measurements) obtained by LC-ECD. Hence, in this study, determining the concentration of selenium drug in commercial selenium supplement products is done using a standard additions procedure. The analytical results are given in Table 2. These results agreed with those obtained using an LC-UV. Representative LC-ECD chromatograms in (Fig. 6A, 6B, 6C) for the selenium supplement drug sample are comparable to a chromatogram of pure standard.

4. Conclusions

We have developed a sensitive green electrochemical procedure for determining organic selenium using flow through voltammetric sensor. It exhibits a good analytical performance using thiol/Au electrode for the electrochemical detection of L-selenomethionine and Se-methylseleno-L-cysteine with a low limit of quantitation, rapid response, a

satisfactory linear range and good stability and selectivity. The presented electrode was simultaneously used to determine L-selenomethionine and Se-methylseleno-L-cysteine in commercial a selenium supplement drug.

誌謝

This work was financially supported by grant MOST 104-2113-M-041-001 from the Taiwan Ministry of Science and Technology.

成果報告自評表

本計畫研究含硒與其衍生物之化妝品與藥品測定方法之研究，近一年經由科技部計畫之執行，已完成目標如下：

- (1) 設計新電化學技術，製配 5 種硫醇 (thiol) 化合物薄膜 (2, 4-thiazolidinedione, 2-mercapto-5-thiazoline, 2-mercaptothiazoline, L-cysteine, thioglycolic acid)，修飾金電極當工作電極。裝入流動式電解槽 (flow cell) 中，當作檢測器並連線高效率液相層析儀，測定甲硒胺酸 (L-selenomethionine) 和甲基硒代半胱胺酸 (Se-methylseleno-L-cysteine) 之含量。
- (2) 此電化學法相對於傳統紫外光偵

測器，具較佳偵測極限 (低於 10 ng mL^{-1}) 和感度 (10^3 次方倍)，並已應用於市售保健食品之含量測定。適合含

硒藥物在人體之吸收代謝動力學研究。

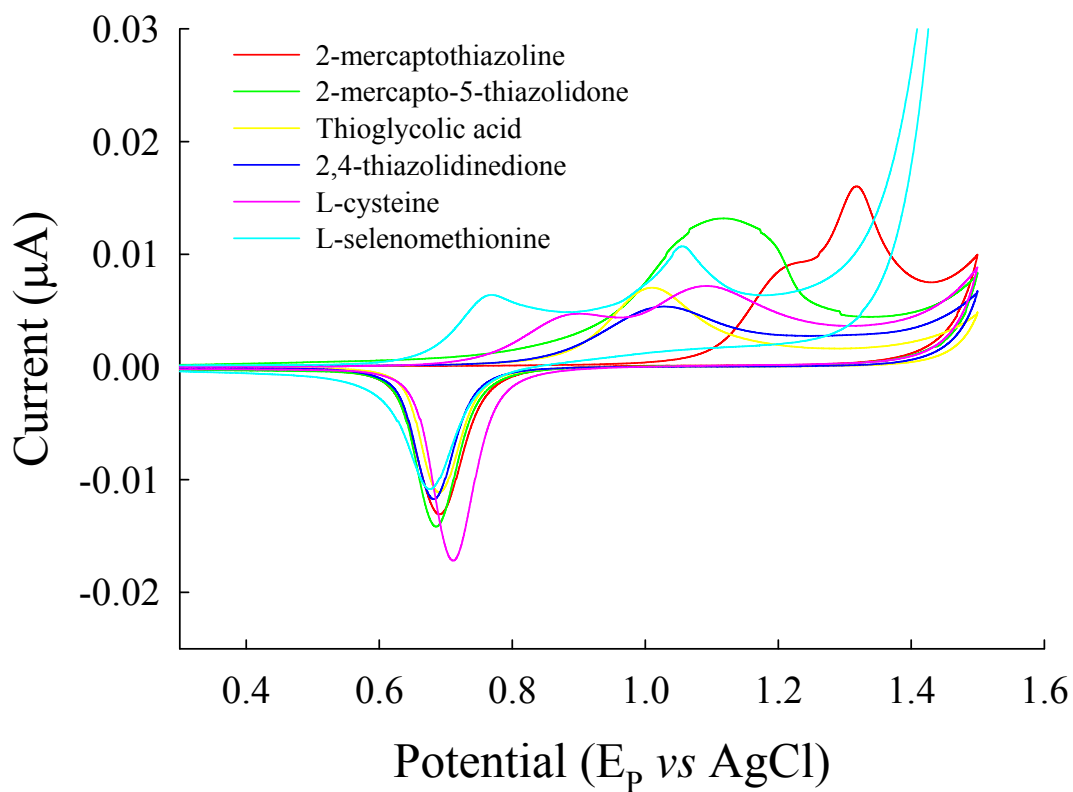
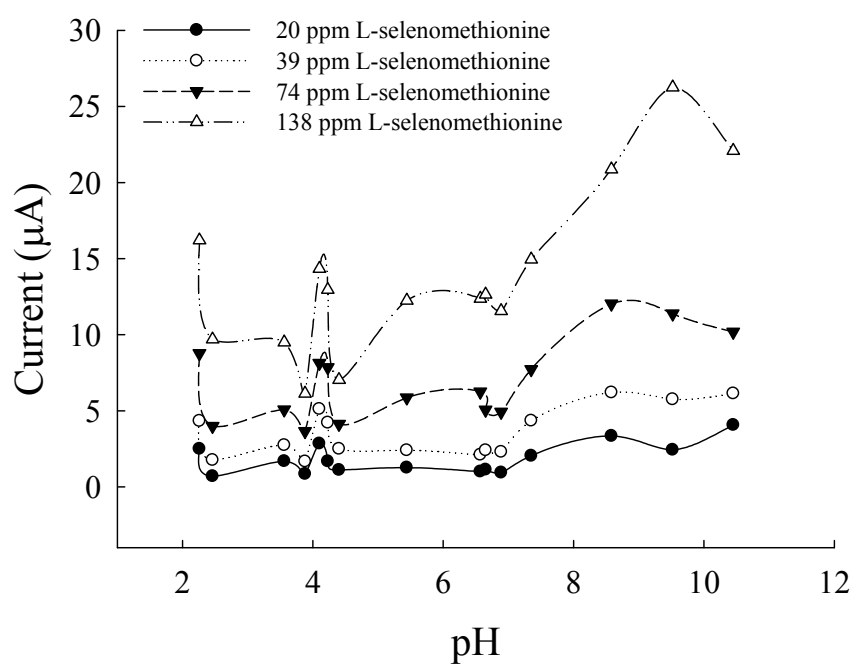


Fig. 1 Cyclic voltammograms of L-selenomethionine and thiol compounds (0.074 mM) on gold electrodes (thiol/Au) at 25 mV/s in acetate buffer (pH = 4.23).

(A)



(B)

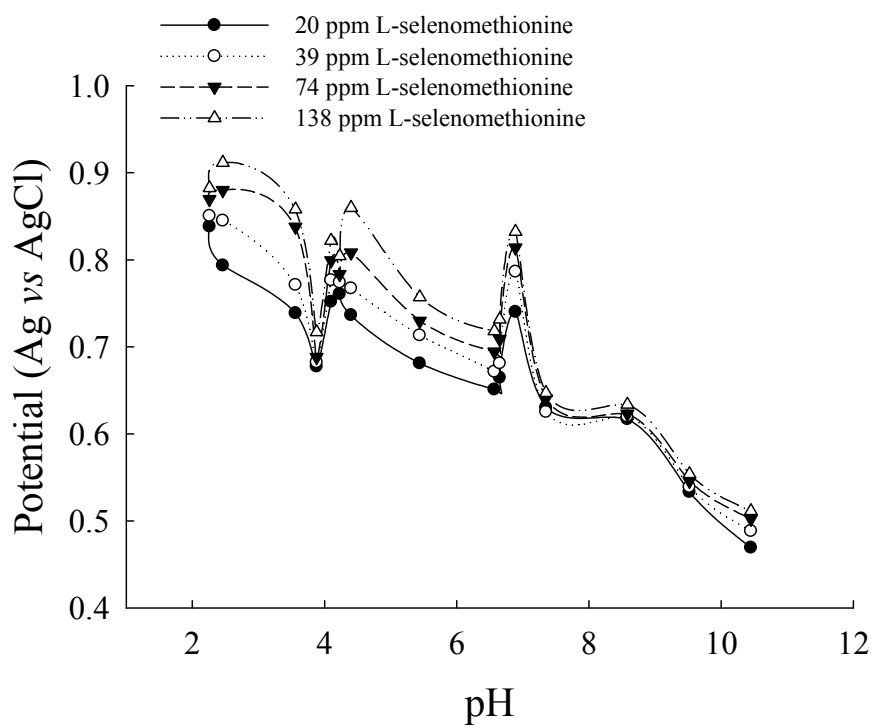


Fig. 2 Effect of pH values on anodic peak in Britton and Robison buffer (pH 2.46 -10.45) containing 20-138 mg L⁻¹ L-selenomethionine (A) the relationships between peak currents and pH and (B) the relationships between potential and pH.

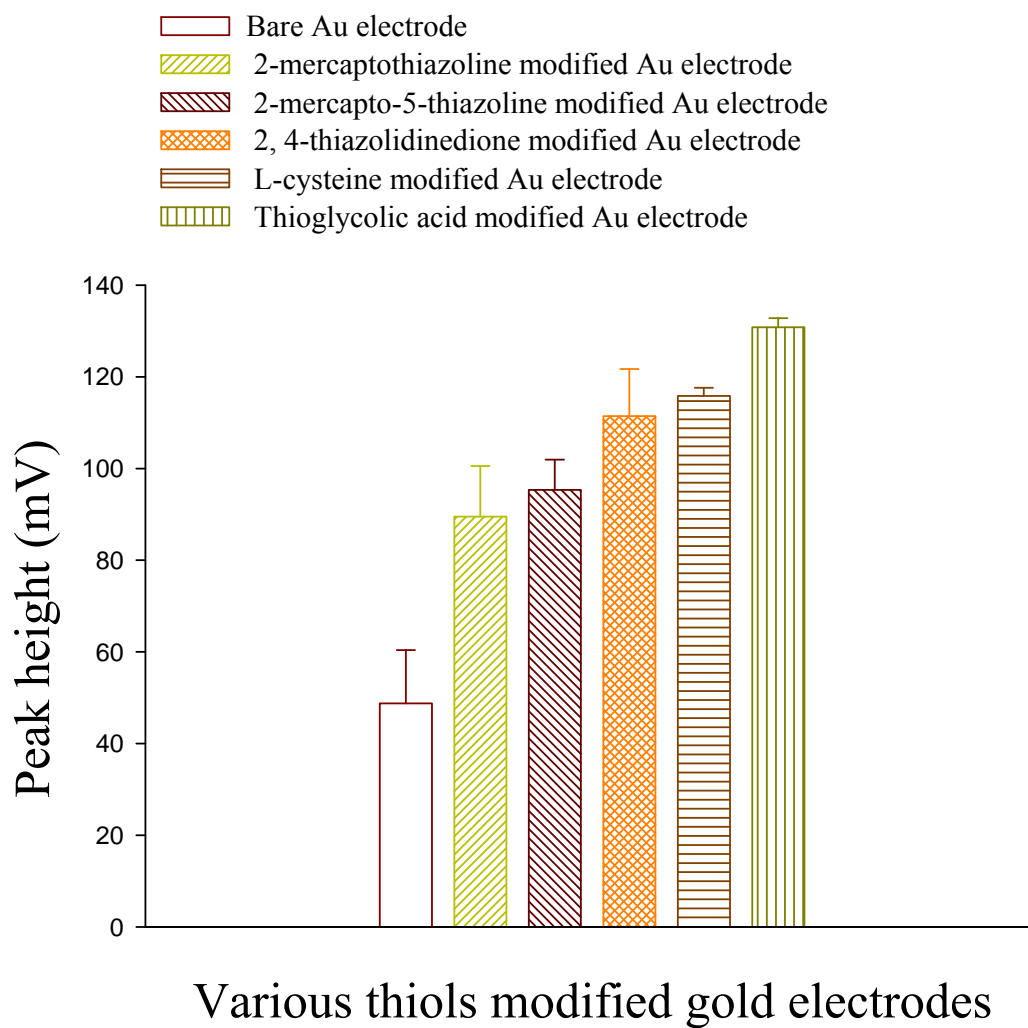


Fig. 3 Compare bare Au and various thiol/Au electrodes of L-selenomethionine (0.4 mgL^{-1}) in a flow-through voltammetric sensor; mobile phase is methanol-water (10:90, v/v).

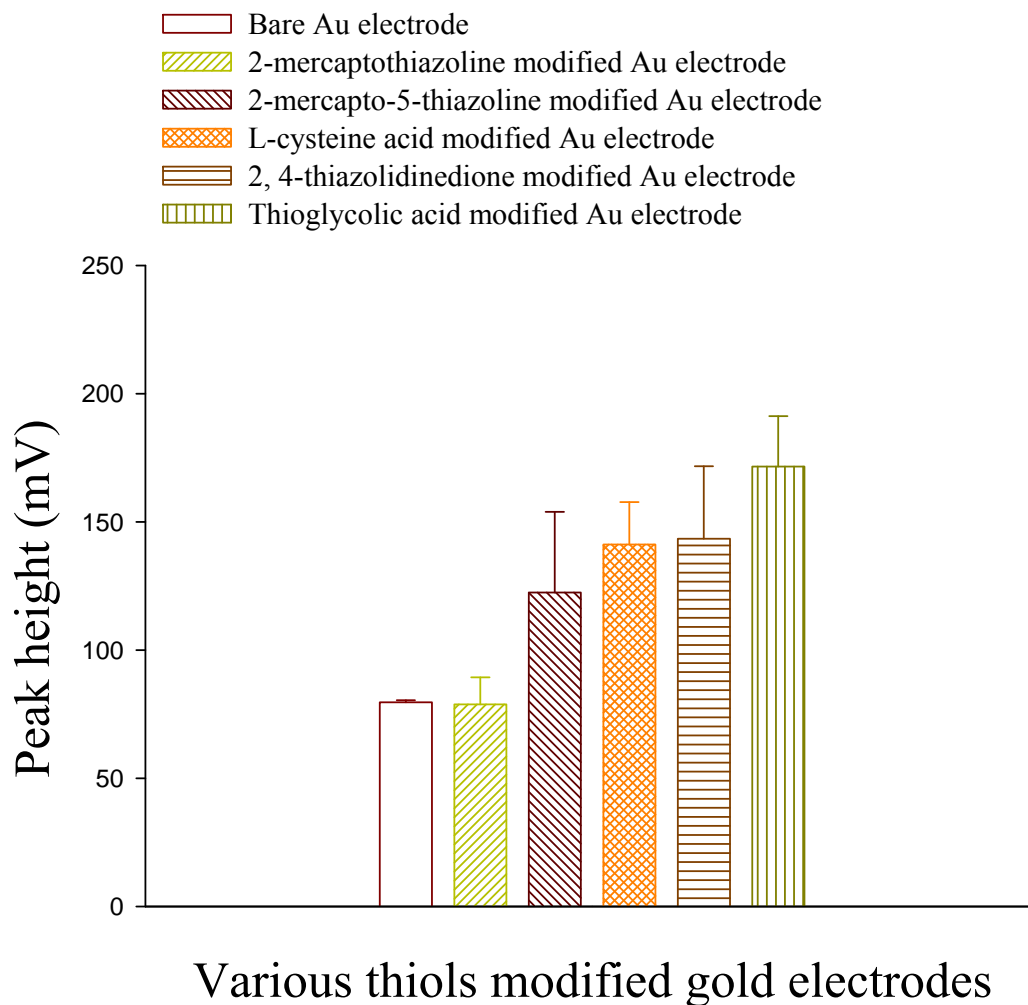


Fig. 4 Compare bare Au and various thiol/Au electrodes of Se-methylselenocysteine (0.4 mgL^{-1}) in a flow-through voltammetric sensor; mobile phase is methanol-water (10:90, v/v).

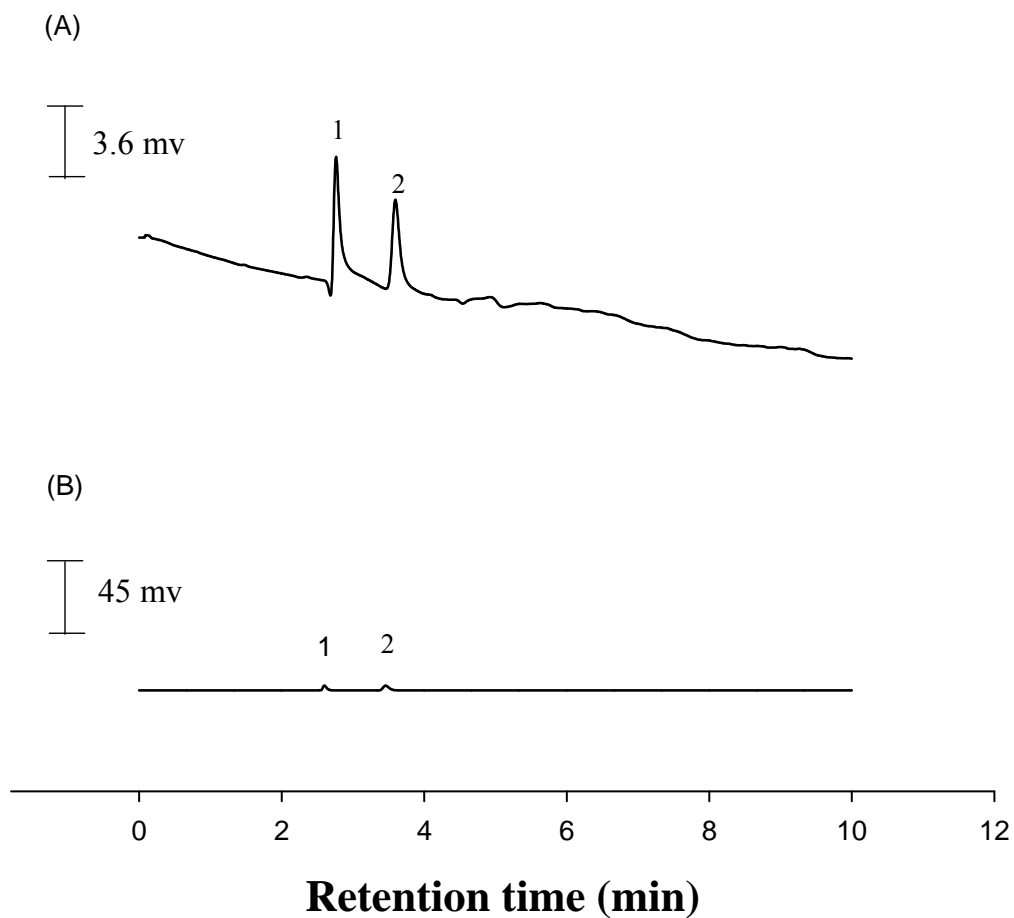


Fig. 5 Chromatograms obtained using (A) LC-ECD (0.4 mgL^{-1}) (B) LC-UV (20 mgL^{-1}) of peak 1 is Se-(methyl)seleno-L-cysteine; and peak 2 is L-selenomethionine standard solutions; ECD at TGA/Au electrode 1.2 V; UV detection at 248 nm. Analysis conditions are identical to those listed in (Fig. 3).

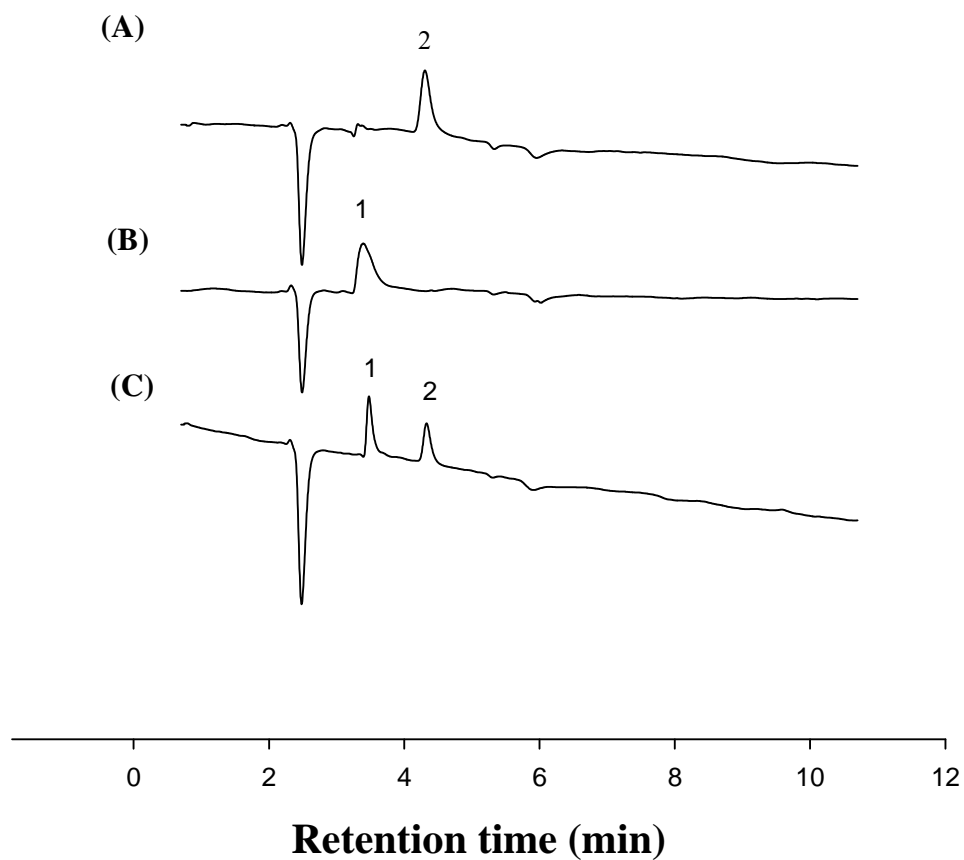


Fig. 6. Chromatograms of peak 1 is Se-(methyl)seleno-L-cysteine; and peak 2 is L-selenomethionine obtained using TGA/Au electrode, (A) and (B) are commercial selenium supplement drugs ; (C) is standard solutions. Analysis conditions are identical to those listed in (Fig. 3).

Table 1 Recoveries of L-selenomethionine and Se-methylseleno-L-cysteine in spiked commercial selenium supplement products by liquid chromatographic with electrochemical and (LC-ECD)

Samples	L-selenomethionine			Se-methylseleno-L-cysteine ^a		
	Added (mg L ⁻¹)	Found ^a (mg L ⁻¹) Mean±SD ^b	Recovery (%)	Added (mg L ⁻¹)	Found (mg L ⁻¹) Mean±SD	Recovery (%)
Sample 1	0.5	0.486±0.007	97.3	----- ^c	----- ^c	----- ^c
	1.0	1.014±0.018	101	----- ^c	----- ^c	----- ^c
	2.0	1.985±0.024	99.2	----- ^c	----- ^c	----- ^c
Sample 2	0.5	0.488 ± 0.046	97.6	----- ^c	----- ^c	----- ^c
	1.0	1.045±0.069	104	----- ^c	----- ^c	----- ^c
	2.0	2.002±0.040	100	----- ^c	----- ^c	----- ^c
Sample 3	0.5	0.507±0.068	101	----- ^c	----- ^c	----- ^c
	1.0	1.036±0.064	103	----- ^c	----- ^c	----- ^c
	2.0	1.993±0.022	99.6	----- ^c	----- ^c	----- ^c
Sample 4	----- ^c	----- ^c	----- ^c	0.5	0.499±0.023	99.8
	----- ^c	----- ^c	----- ^c	1.0	1.011±0.031	101
	----- ^c	----- ^c	----- ^c	2.0	1.995±0.013	99.7
Sample 5	----- ^c	----- ^c	----- ^c	0.5	0.549±0.023	105
	----- ^c	----- ^c	----- ^c	1.0	1.031±0.014	103
	----- ^c	----- ^c	----- ^c	2.0	2.034±0.032	101

^a Number of determination (N=3).

^b S. D, Standard deviation

^c Not determined

Table 2 Analytical results of determination of L-selenomethionine and Se-methylseleno-L-cysteine in commercial selenium supplement products by liquid chromatographic with and electrochemical and (LC-ECD) ultraviolet detection (LC-UV)

Samples	L-selenomethionine		Se-methylseleno-L-cysteine ^a	
	Concentration (% w/w) N = 3 ^a		Concentration (% w/w) N = 3 ^a	
	LC-ECD	LC-UV	LC-ECD	LC-UV
Sample 1	0.035±(3.4)	0.036±(2.8)	----- ^c	----- ^c
Sample 2	0.101± (1.4)	0.102± (2.0)	----- ^c	----- ^c
Sample 3	0.131± (3.0)	0.133±(3.1)	----- ^c	----- ^c
Sample 4	----- ^c	----- ^c	0.138± (2.5)	----- ^c
Sample 5	----- ^c	----- ^c	0.875± (0.4)	----- ^c

^a Number of determination (N=3).

^b Values in parentheses indicate R. S. D.

^c Not determined

科技部補助計畫衍生研發成果推廣資料表

日期:2016/10/05

科技部補助計畫	計畫名稱: 含硒與其衍生物之化妝品與藥品測定方法之研究
	計畫主持人: 王來好
	計畫編號: 104-2113-M-041-001- 學門領域: 分析化學
無研發成果推廣資料	

104年度專題研究計畫成果彙整表

計畫主持人：王來好			計畫編號：104-2113-M-041-001-			
計畫名稱：含砒與其衍生物之化妝品與藥品測定方法之研究						
成果項目			量化	單位	質化 (說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等)	
國內	學術性論文	期刊論文		0	篇	
		研討會論文		1		
		專書		0	本	
		專書論文		0	章	
		技術報告		0	篇	
		其他		0	篇	
	智慧財產權及成果	專利權	發明專利	申請中	0	件
				已獲得	0	
			新型/設計專利		0	
		商標權		0		
		營業秘密		0		
		積體電路電路布局權		0		
		著作權		0		
		品種權		0		
		其他		0		
	技術移轉	件數		0	件	
		收入		0	千元	
	國外	學術性論文	期刊論文		0	篇
			研討會論文		1	
			專書		0	本
專書論文			0	章		
技術報告			0	篇		
其他			0	篇		
智慧財產權及成果		專利權	發明專利	申請中	0	件
				已獲得	0	
			新型/設計專利		0	
		商標權		0		
		營業秘密		0		
		積體電路電路布局權		0		
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其他		0				

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		收入	0	千元	
參與計畫人力	本國籍	大專生	2	人次	
		碩士生	0		
		博士生	0		
		博士後研究員	0		
		專任助理	1		
	非本國籍	大專生	0		
		碩士生	0		
		博士生	0		
		博士後研究員	0		
		專任助理	0		
其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)		無			

科技部補助專題研究計畫成果自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現（簡要敘述成果是否具有政策應用參考價值及具影響公共利益之重大發現）或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

達成目標

未達成目標（請說明，以100字為限）

實驗失敗

因故實驗中斷

其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形（請於其他欄註明專利及技轉之證號、合約、申請及洽談等詳細資訊）

論文： 已發表 未發表之文稿 撰寫中 無

專利： 已獲得 申請中 無

技轉： 已技轉 洽談中 無

其他：（以200字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性，以500字為限）

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4. 主要發現

本研究具有政策應用參考價值： 否 是，建議提供機關

（勾選「是」者，請列舉建議可提供施政參考之業務主管機關）

本研究具影響公共利益之重大發現： 否 是

說明：（以150字為限）