CHAPTER 3

ANODIC STRIPPING ANALYSIS OF THALLIUM (I)

Polarcgraphic determination of $1 X 10^{-3} - 5 X 10^{-1}\%$ and $5 X 10^{-6} - 5 X 10^{-3}\%$ thallium in salts and single **crystal** of KI, NaI and CsI were possible by using the supporting electrolyte as 1.6 M NH_4OH and 2 M KOH, respectively (17). A single reversible polarographic wave of Tl (I) in aqueous melted $Ca (NO_3)_2 \cdot 4H_2O$, $Ca (NO_3)_2 \cdot 4D_2O$, $LiNO_3 \cdot 3H_2O$ and $CaCl_2 \cdot 6H_2O$ given a linearity of the limiting current to Tl (I) concentration was reported (18). The polarographic behavior of Tl (I) were also studied in 1-14 M NaOH or KOH (19), as well as in 1-14 M H_2SO_4 (20). Using a Pt microelectrode, the anodic oxidation of Tl (I) in the pH range of 11-14 provided a limiting current of Tl (I) which was proportional to the concentration of Tl (I) and to the square root of the rate of rotation of electrode and the end product of this reaction was proved to be Tl_2O_3 (21). Tl (I) also gave a well defined polarogram in 0.01 M succinic acid at pH $\sim$ 3.0 with a half-wave potential of -0.50 V vs SCE (23). The complex formation of Tl (I) with ethylenebis (3-mercaptopropionate) (24), ethyl thioglyconate (25), with N, N-dihydroxyethylglycine (26), with the amines (mono-, di-, triethanolamine), and with N-methyldiethanolamine (27, 28) was investigated by polarographic method. Polarographic properties of complexes of Tl (I) with N-cinnamoyl-N-phenylhydroxylamine (29), with N-phenylcinnamoylhydroxamic acid (30), and with N-benzoyl phenylhydroxylaminates (31) were also studied in nonaqueous media. The effects of some surfactants (gelatin, Triton X-100, and few detergents) (32), several terpenes and their derivatives (33) were examined on the reduction of Tl (I) on a dropping mercury electrode. The millimolar concentration of Tl (I) in the mixture of Pb and Tl was polarographically determined in ethylenediamine containing 3% mannitol (34), as well as trace thallium was analyzed polarographically in hexamethylphosphoramide medium (35). In addition, the polarographic behavior of Tl (I) in water-free purified pyridine (36), and the oscillopolarographic study of Tl (I) in 0.5 M HNO_3 supporting electrolyte (37) were reported.

Amperometric titration of Tl (I) with thioacetamide (CH_3CSNH_2) in NaOH - glycine buffer which Zn (II) did not interfere even at a 1000-fold excess (38), with a solution of sodium tetraphenylborate (39), with dithiotrihydroxymethylaminomethane in ammonical ammonium tartrate-KNO_3 supporting electrolyte (40), with N-Bis (β-aminoethyl-dithiocarbamic acid)(41), and with lead tetra-acetate in 0.3 M HCl as supporting electrolyte (42) were described. The automatic potentiometric titration of Tl (I) in acetone with a standard solution of KOH in isopropyl alcohol was also proposed (43).

The electrochemical concentration of Tl (I) impurities in GaAs sample on a graphite electrode was possible with a sensitivity of 5×10^{-4} mg cm^{-3} (44). Chronoamperometric study of the anodic oxidation of Tl (I) in alkali solution (0.05 - 10 M KOH) provided a first order in Tl (I) with the rate constant of 4×10^{-2} cm sec^{-1}(45). In addition, chronopotentiometric behavior of Tl (I) on a graphite electrode was reported in reference 46 and 47.

The voltammetric behavior of Tl (I) and Tl (III) in 1 M $HClO_4$ on a smooth Pt and on variously platinized Pt were studied in reference 48. The application of anodic potential-step stripping voltammetry to the determination of Tl (I) was proposed with a standard deviation in the peak height measurement of 3% for 0.1 or 0.2 ppm Tl (I) (49). The double anodic polarographic peaks of thallium on a graphite electrode were found in the following supporting electrolyte, 0.1 M KCl, 0.1 M $HClO_4$, 0.1 M KSCN and 0.5 M KNO_3(50). The sensitivity for the ASV of thallium was improved by using Hg-plated carbon electrode (51). A tubular mercury covered graphite electrode which was developed for ASV was evaluated by using Tl in the presence of 10^{-2}M EDTA; linear calibrations of Tl peak height vs concentration were obtained over the range $2 X 10^{-7} - 1 X 10^{-6}$M, $2 X 10^{-8} - 1 X 10^{-7}$M and $2 X 10^{-9} - 1 X 10^{-8}$M at plating time of 3, 8 and 30 minutes, respectively (52). Thallium in urine (53), and in high purity cadmium (54) were determined by ASV method. The determination of Tl (I) in the presence of Pb (II) and Cu (in 1000 fold excess) by differential pulse anodic stripping voltammetry with a thin Hg film electrode (Hg plated in situ on the GCE) in unstirred KNO_3 solution at pH 3.5 was reported (55). Stripping voltammetry of thallium at disproportionate concentration was examined by using the amalgam concentration (56). In addition, trace amounts of Tl in copper alloys were determined by inverse voltammetry (57).

The reduction of Tl at a Hg-pool electrode in ca. 50% HF by both a.c. and d.c. voltammetry was investigated, the limit of detection of Tl (I) with a reproducibility of 2% was 5 X 10^{-6}M and 1 X 10^{-6}M by the a.c. and d.c. methods, respectively (58). The electrodeposition of Tl on the GCE in 50% HF by d.c., a.c., pulse and anodic stripping voltammetric method was also described in reference 59. For the anodic stripping microdetermination of trace amounts of Tl (I) by linear sweep, superimposed alternating current and pulse voltammetry, a rotating Hg amalgamated Cu-disk electrode was used and the detection limit was found to be 4.5 X 10^{-10}M Tl (I) in 10^{-4}M acetic acid and 10^{-4}M sodium acetate supporting electrolyte (60).

In this chapter the conditions for anodic stripping analysis of Tl (I) at a glassy carbon electrode and the sensitivity of Tl (I) in the electrolyte chosen are reported.

3.1 Evaluation of electrolyte

The cathodic voltammetric behavior of thallium (I) was studied in many supporting electrolytes, i.e., KNO_3, KCl, NaSCN, $NaClO_4$, HNO_3, HCl, acetic acid and acetate buffers. It is seen that one cathodic peak of thallium is obtained in the voltammogram of 1.00 X 10^{-3}M Tl (I) in every supporting electrolyte mentioned (see Figure 3.1), and the well defined peak is shown in 0.1 M KNO_3, 0.1 M KCl, 1 M $NaClO_4$, 0.2 M NaSCN and acetate buffer at pH5. Its peak potential and peak current are listed in Table 3.1.

3.1.1 potassium nitrate

Corresponding to the cathodic peak of thallium in various

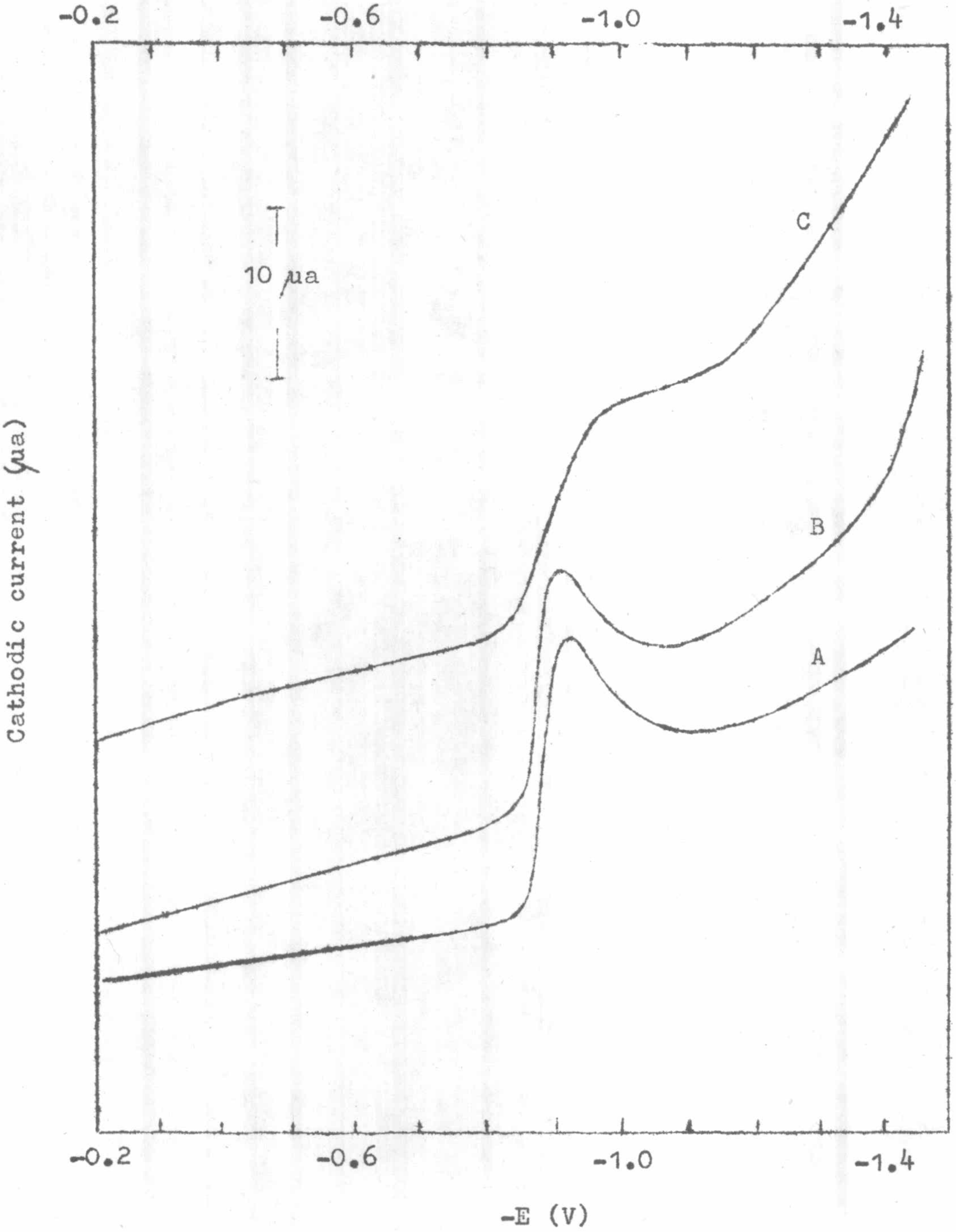

Figure 3.1 Cathodic voltammograms of 1.00 X 10^{-3}M Tl (I) in A) 0.1 M KNO_3, B) acetate buffer pH 5.0, C) 0.2 M acetic acid.

concentrations of KNO_3 showed at ca. -0.93 V (see Table 3.1), the electrodeposition of Tl (I) in KNO_3 was performed at -1.0 V. The optimum concentration of KNO_3 as supporting electrolyte for ASV of Tl (I) was tested by using 1.00×10^{-4}M and 4.00×10^{-5}M Tl (I) solutions in 0.1 M, 0.2 M, and 0.5 M KNO_3. The results obtained are shown in Table 3.2. As shown in Table 3.2, the anodic peak current does not show a great tendency in changing while the concentration of potassium nitrate increases. Therefore, the lowest concentration of KNO_3 electrolyte (0.1 M) was chosen for economy and for preventing from a high resistance effect.

The effect of pH on the anodic peak current of thallium in 0.1 M KNO_3 was also investigated. It was observed that no significant pH affected on the anodic peak current of thallium for the ASV of 1.00×10^{-4}M - 4.00×10^{-6}M Tl (I) in the pH range of 6.25 - 2.15, except the ASV of 4.00×10^{-6}M Tl (I) at the pH below 3.5 (see Table 3.3).

Table 3.1 The cathodic voltammetric behavior of 1.00×10^{-3}M $TlNO_3$ in various supporting electrolytes.

Supporting Electrolyte	$E_{p,c}$ V	$i_{p,c}$ μa
0.10 M KNO_3	-0.93	12.5
0.10 M KCl	-0.92	10.0
1.0 M $NaClO_4$	-0.92	12.5
0.20 M NaSCN	-1.00	8.0
0.10 M HNO_3	-0.96	4.75
0.01 M HCl	-0.95	4.50
0.20 M HOAc	-0.98	5.0
acetate buffer pH 5.0	-0.92	12.0

Table 3.2 The ASV behavior of thallium in various concentrations of potassium nitrate for a deposition of 5 minutes at - 1.0 V.

A) for 1.00 X 10^{-4} M Tl (I)

Conc. of KNO_3 M	$E_{p,a}$ V	$i_{p,a}$* μa
0.1	-0.67	112.20 ± 5.52
0.2	-0.68	109.74 ± 3.32
0.5	-0.69	113.00 ± 3.60

B) for 4.00 X 10^{-5} M Tl (I)

Conc. of KNO_3 M	$E_{p,a}$ V	$i_{p,a}$* μa
0.1	-0.74	45.90 ± 0.60
0.2	-0.75	49.25 ± 4.75
0.5	-0.77	49.75 ± 1.25

* average anodic peak current ± average deviation of more than 3 trials

Table 3.3 The effect of pH on the ASV of thallium in 0.1 M KNO_3- HNO_3 system.

A) 1.00 X 10^{-4} M Tl (I), deposited at -1.0 V for 3 minutes

pH	$E_{p,a}$ V	$i_{p,a}^{*}$ µa
6.25^{+}	-0.68	99.5 ± 3.5
5.35	-0.67	99.0 ± 2.0
4.20	-0.67	102.3 ± 3.1
3.15	-0.68	99.0 ± 2.0
2.15	-0.70	98.1 ± 3.1
1.30	++	++

B) 1.00 X 10^{-5} M Tl (I), deposited at -1.0 V for 10 minutes

5.60^{+}	-0.74	31.63 ± 4.38
4.15	-0.75	22.50 ± 0.50
3.15	-0.75	23.00 ± 3.00
2.15	-0.76	23.50 ± 0.50
1.45	++	++

Table 3.3 (continued)

C) 4.00×10^{-6} M Tl (I), deposited at -1.0 V for 10 minutes

pH	$E_{p,a}$ V	$i_{p,a}^{*}$ μa
5.85[+]	-0.94	1.24 ± 0.16
5.10	-0.94	1.41 ± 0.01
4.85	-0.94	1.32 ± 0.08
4.40	-0.94	1.28
3.50	++	++

[*] average anodic peak current ± average deviation of more than 3 trials.

[+] no addition of HNO_3

[++] due to the high charging current no base-line can be drawn.

For economy and simplicity, the anodic stripping analysis of Tl (I) was hence studied in 0.1 M KNO_3 solution; pH 5.60 - 6.25.

3.1.2 potassium chloride

The ASV behavior of Tl (I) in KCl supporting electrolyte was studied at the concentration of 0.1 M, 0.2 M, and 1.0 M KCl. The electrodeposition potential used herein is -1.0 V due to the cathodic peak of Tl (I) appears at -0.92 V (see Table 3.1). The anodic voltammetric data obtained are illustrated in Table 3.4. It is seen that the ASV behaviors of Tl (I) in KNO_3 and in KCl are insignificantly different (see Tables 3.2 and 3.4). Thus, the anodic stripping analysis of Tl (I) can be performed in KCl solution at the concentration of 0.1 M to 1.0 M KCl.

Table 3.4 The ASV behavior of thallium in various concentrations of potassium chloride for a deposition of 5 minutes at -1.0 V.

A) for 1.00 X 10^{-4} M Tl (I)

Conc. of KCl M	$E_{p,a}$ V	$i_{p,a}^{*}$ μa
0.1	-0.67	116.84 ± 4.99
0.2	-0.69	118.62 ± 6.30
1.0	-0.72	122.87 ± 6.10

B) for 4.00 X 10^{-5} M Tl (I)

Conc. of KCl M	$E_{p,a}$ V	$i_{p,a}^{*}$ μa
0.1	-0.74	48.25 ± 1.25
0.2	-0.75	56.75 ± 2.75
1.0	-0.78	58.75 ± 2.25

[*] average anodic peak current ± average deviation of more than 3 trials.

3.1.3 acetic acid

Owing to the cathodic peak of Tl (I) in acetic acid showed at ca. -0.98 V (see Table 3.1), the electrodeposition of Tl (I) at -1.0 V was selected. A series of concentrations of acetic acid (0.1 M - 3.0 M) was tried for contributing an optimum acetic acid content for the anodic stripping analysis of Tl (I). The ASV data are shown in Table 3.5. A well defined anodic peak of thallium appears in every anodic stripping voltammogram of 1.00 X 10^{-4} M Tl (I) in the acetic acid content varying from 0.1 M to 3.0 M, and a maximum peak current results in the 2.5 M acetic acid (see Table 3.5).

3.1.4 acetate buffer

The cathodic voltammogram of Tl (I) in the acetate buffer showed a well defined peak at ca. -0.92 V (see Table 3.1), thus, the electrolytic conditions for ASV of Tl (I) were investigated by using the electrodeposition potential of -1.0 V. The anodic stripping voltammetric behaviors of Tl (I) in various pH of acetate buffer system are listed in Table 3.6 and a plot of the anodic peak current against pH of the test solution is shown in Figure 3.2.

Table 3.5 The ASV behavior of thallium in various concentrations of acetic acid, using 1.00 X 10^{-4} M Tl (I) and a 2 minute deposition at -1.0 V.

Conc. of acetic acid M	$E_{p,a}$ V	$i_{p,a}$* µa	Remark
0.1	-0.78	4.31 ± 0.25	a well-defined peak
1.0	-0.66	24.35 ± 2.16	
2.5	-0.66	28.48 ± 0.32	
3.0	-0.66	13.43 ± 2.43	

Table 3.6 The ASV behavior of 1.00 X 10^{-5} M Tl (I) in acetate buffer at various pH, using a deposition time of 5 minutes at -1.0 V.

acetate buffer pH	$E_{p,a}$ V	$i_{p,a}$* µa
3.6	-0.55	1.30 ± 0.10
4.1	-0.55	1.80
4.6	-0.56	1.12 ± 0.15
	-0.80	2.76 ± 0.04
5.0	-0.56	0.60 ± 0.10
	-0.82	3.31 ± 0.19
5.6	-0.84	1.84

* average anodic peak current ± average deviation of more than 3 trials.

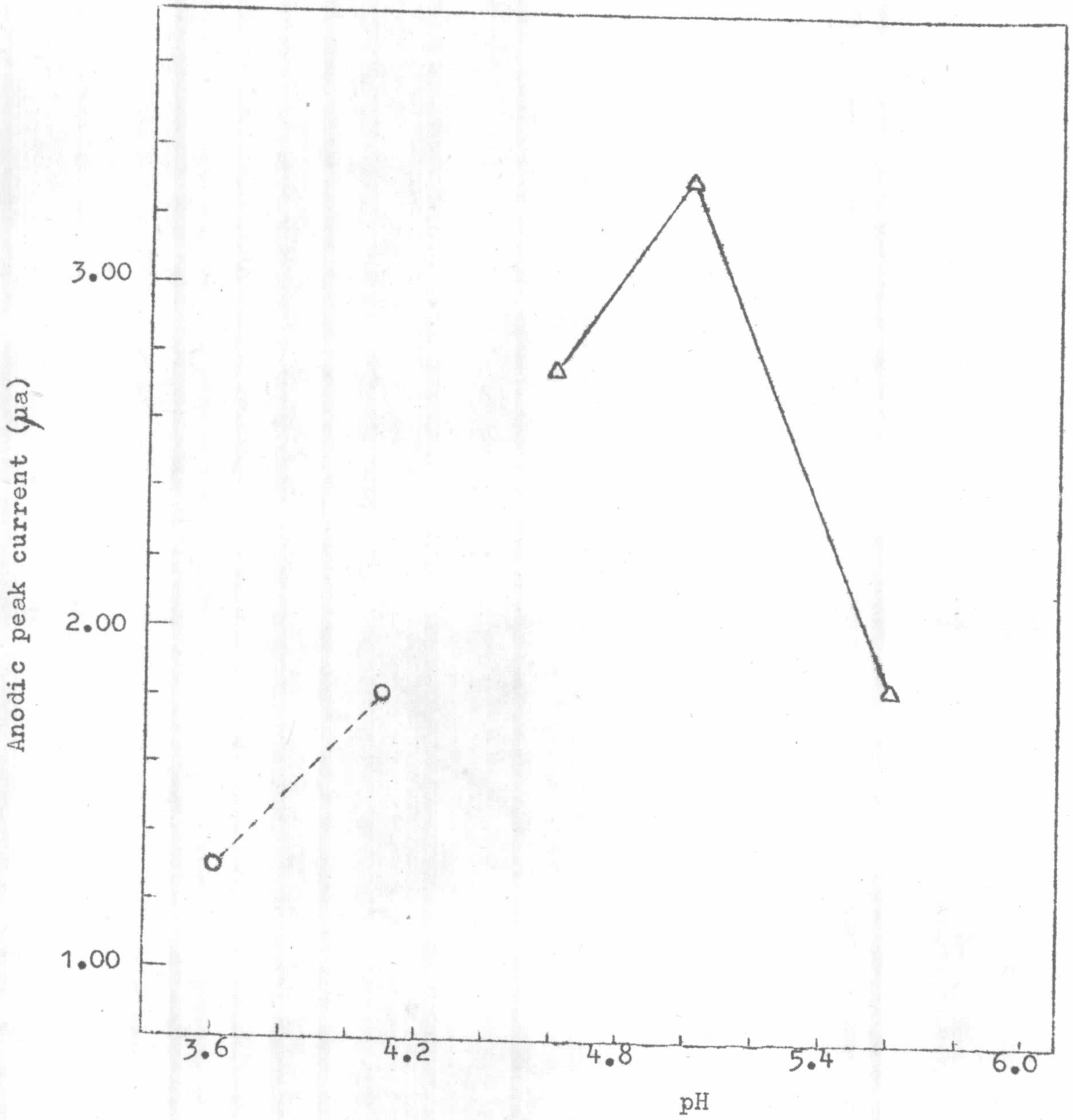

Figure 3.2 Dependence of the anodic peak current of thallium on pH of acetate buffer,

○ peak current at ca. -0.55 V

△ peak current at ca. -0.82 V.

From Table 3.6 it is seen that an anodic stripping peak of Tl (I) appears at -0.55 V for the lower pH solution (3.6 - 4.1) and at ca. -0.82 V for the higher pH solution (5.6). In the intermediate pH solution (4.6 - 5.0), two anodic stripping peaks of Tl (I) are shown at -0.56 V and -0.82 V, respectively, and the anodic peak current at -0.56 V becomes smaller as the pH is higher (see Figure 3.3). The maximum anodic peak current of thallium is given in the acetate buffer solution of pH 5.0 at -0.82 V.

3.1.5 other supporting electrolytes

The anodic stripping analysis of Tl (I) in $NaClO_4$ was not attempted owing to the cathodic voltammogram obtained provided a similar behavior as that of Tl (I) in 0.1 M KNO_3 (see Table 3.1) and the analytical grade of $NaClO_4$ was more expensive than KNO_3.

Sodium thiocyanate is a light sensitive agent and it forms numerous thiocyanate complexes with thallium (2). Thus the ASV of Tl (I) in this electrolyte was avoided.

A comparison of the ASV of Tl (I) in the supporting electrolyte mentioned above is concluded in Table 3.7. Using 1.00×10^{-4} M Tl (I) and 2 minutes deposition at -1.0 V, it is observed that the anodic peak current of thallium increases in the order:

2.5 M acetic acid $<$ acetate buffer pH 5.0 $<$ 0.1 M $KNO_3 \approx$ 0.1 M KCl.

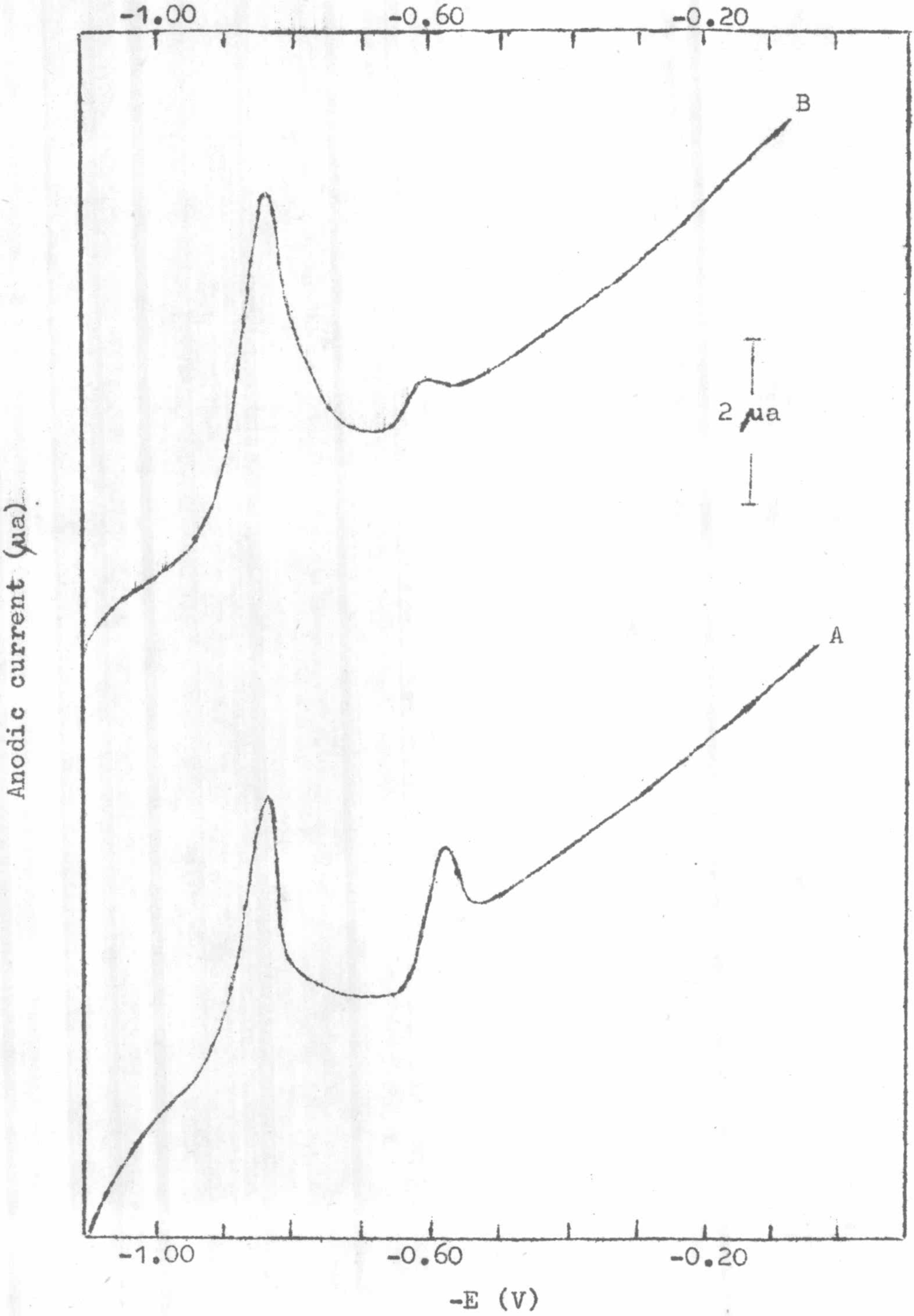

Figure 3.3 Anodic voltammograms of 1.00 X 10^{-5}M Tl (I) in acetate buffer: A) pH 4.6, B) pH 5.0, using 5 minute electrodeposition at -1.0 V.

Table 3.7 A comparison of the ASV of 1.00 X 10^{-4}M Tl (I) deposited at -1.0 V for 2 minutes in various supporting electrolytes.

Supporting electrolyte	$E_{p,a}$ V	$i_{p,a}$* μa
0.1 M KNO_3	-0.71	59.57 ± 2.67
0.1 M KCl	-0.71	58.27 ± 2.41
acetate buffer pH 5.0	-0.70	43.94 ± 1.97
2.5 M acetic acid	-0.66	28.48 ± 0.32

* average anodic peak current ± average deviation of more than 3 trials

Some anodic stripping voltammograms of 4.00 X 10^{-5}M Tl (I) in 0.1 M KNO_3, 0.1 M KCl, and acetate buffer at pH 5.0, using 4.00 X 10^{-5}M Tl (I) and 5 minute deposition at -1.0 V, are shown in Figure 3.4.

3.2 Stripping analysis

The anodic stripping analysis of thallium (I) was firstly performed in 0.1 M KNO_3 electrolyte using a deposition time of 5 minutes at -1.0 V and having a potential scan from -1.2 to 0.0 V. Then the ASV of Tl (I) were investigated in 0.1 M KCl and in acetate buffer pH 5.0, respectively. The results are tabulated and compared in Table 3.8. In the concentration range of 1.00 X 10^{-4}M to 4.00 X 10^{-5}M Tl (I), the anodic stripping voltammogram of Tl (I) in each supporting electrolyte shows a single anodic peak at ca. -0.71 V,

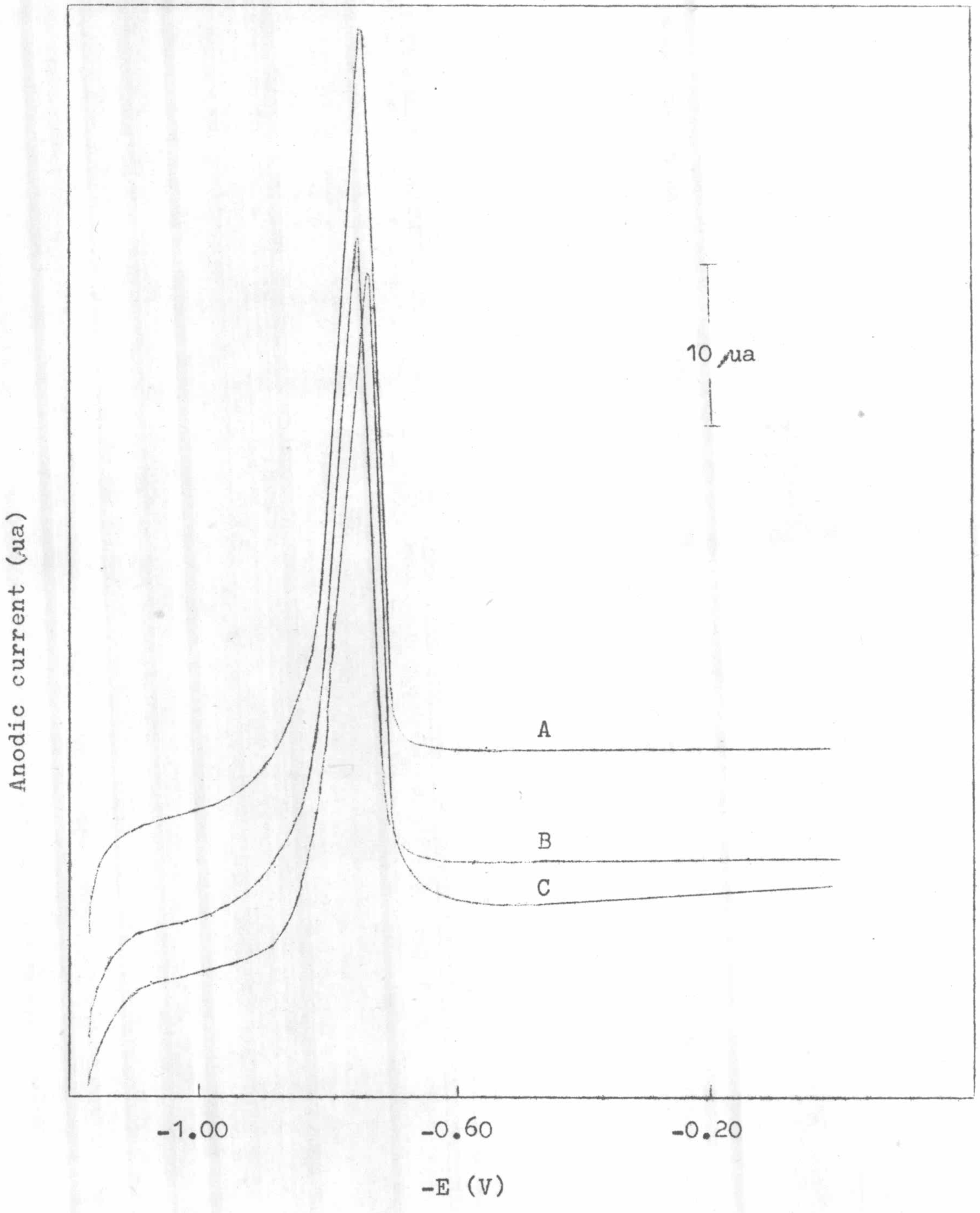

Figure 3.4 Anodic voltammograms of 4.00×10^{-5} M $TlNO_3$ compared in various supporting electrolytes, using a 5-minute electrodeposition at -1.0 V in **A**) 0.1 M KNO_3 B) 0.1 M KCl , and C) acetate **buffer** pH 5.0 .

Table 3.8 A comparison of data of anodic stripping analyses of thallium (I) in various electrolytes, using a deposition time of 5 minutes at -1.0 volts, having a range of potential scan from -1.2 to + 0.0 volts.

Conc. of Tl (I)	0.1 M KNO_3		0.1 M KCl		acetate buffer pH 5.0	
M	$E_{p,a}$ (V)	$i^{*}_{p,a}$ (μa)	$E_{p,a}$ (V)	$i^{*}_{p,a}$ (μa)	$E_{p,a}$ (V)	$i^{*}_{p,a}$ (μa)
1.00×10^{-4}	-0.67	112.20 ± 5.52	-0.67	116.84 ± 4.99	-0.64	92.63 ± 1.19
8.00×10^{-5}	-0.69	99.35 ± 1.23	-0.68	90.56 ± 1.41	-0.67	78.73 ± 1.02
6.00×10^{-5}	-0.71	72.33 ± 1.24	-0.71	66.40 ± 4.17	-0.70	53.90 ± 2.90
4.00×10^{-5}	-0.74	45.90 ± 0.60	-0.74	48.25 ± 1.25	-0.73	39.10 ± 1.87
2.00×10^{-5}	-0.77	15.55 ± 0.70	-0.78	16.43 ± 0.83	-0.76	15.60 ± 0.20
1.00×10^{-5}	-0.87	2.28 ± 0.15	-0.88	2.25 ± 0.13	-0.86	1.43 ± 0.04
0.80×10^{-5}	-0.88	1.38 ± 0.02	-0.90	1.58 ± 0.09		

* average anodic peak current ± average deviation of more than four trials.

and becomes to be two overlapped peaks ($E_{p,a}$ = -0.77 V and -0.85 V) in the concentration of 2.00 X 10^{-5}M Tl (I), then turns in one single anodic peak at ca. -0.87 V in the concentration of 1.00 X 10^{-5} - 0.80 X 10^{-5}M Tl (I) (see Figure 3.5). This phenomenon was also observed by Moskovskikh (50). The two overlapped peaks can be solved by performing the electrodeposition of 2.00 X 10^{-5}M Tl (I) at a shorter time (2 or 3 minutes) and a single anodic peak appears at -0.76 V (see Tables 3.9 and 3.10). Thus, the condition for ASV of 1.00 X 10^{-4}M - 1.00 X 10^{-5}M Tl (I) was improved by shortening the electrodeposition time to be 3 minutes. The anodic stripping analysis of 1.00 X 10^{-4}M - 1.00 X 10^{-5}M Tl (I) in either 0.1 M KNO_3 or acetate buffer at pH 5.0 were reexamined by a 3 minute deposition. Their ASV behaviors are shown in Tables 3.9 and 3.10.

To obtain the highest sensitivity for ASV of Tl (I), the longer deposition times, 10 minutes and 20 minutes, were tried. The ASV data for determining 1.00 X 10^{-5}M - 1.00 X 10^{-6}M Tl(I), using 10 minute deposition are shown in Tables 3.9 and 3.10. For 20 minute deposition of 1.00 X 10^{-6}M Tl (I) in either 0.1 M KNO_3 or acetate buffer at pH 5.0, the anodic stripping peak current given is not much different from that of 10 minute deposition. Thus the ASV of Tl (I) at concentration below 1.00 X 10^{-6}M Tl (I) was not studied. The detection limit for ASV of Tl (I) both in 0.1 M KNO_3 and in acetate buffer at pH 5.0 is 1.00 X 10^{-6}M Tl (I).

The anodic peak current obtained from each condition for ASV of Tl (I) is directly proportional to the concentration of Tl (I) (see

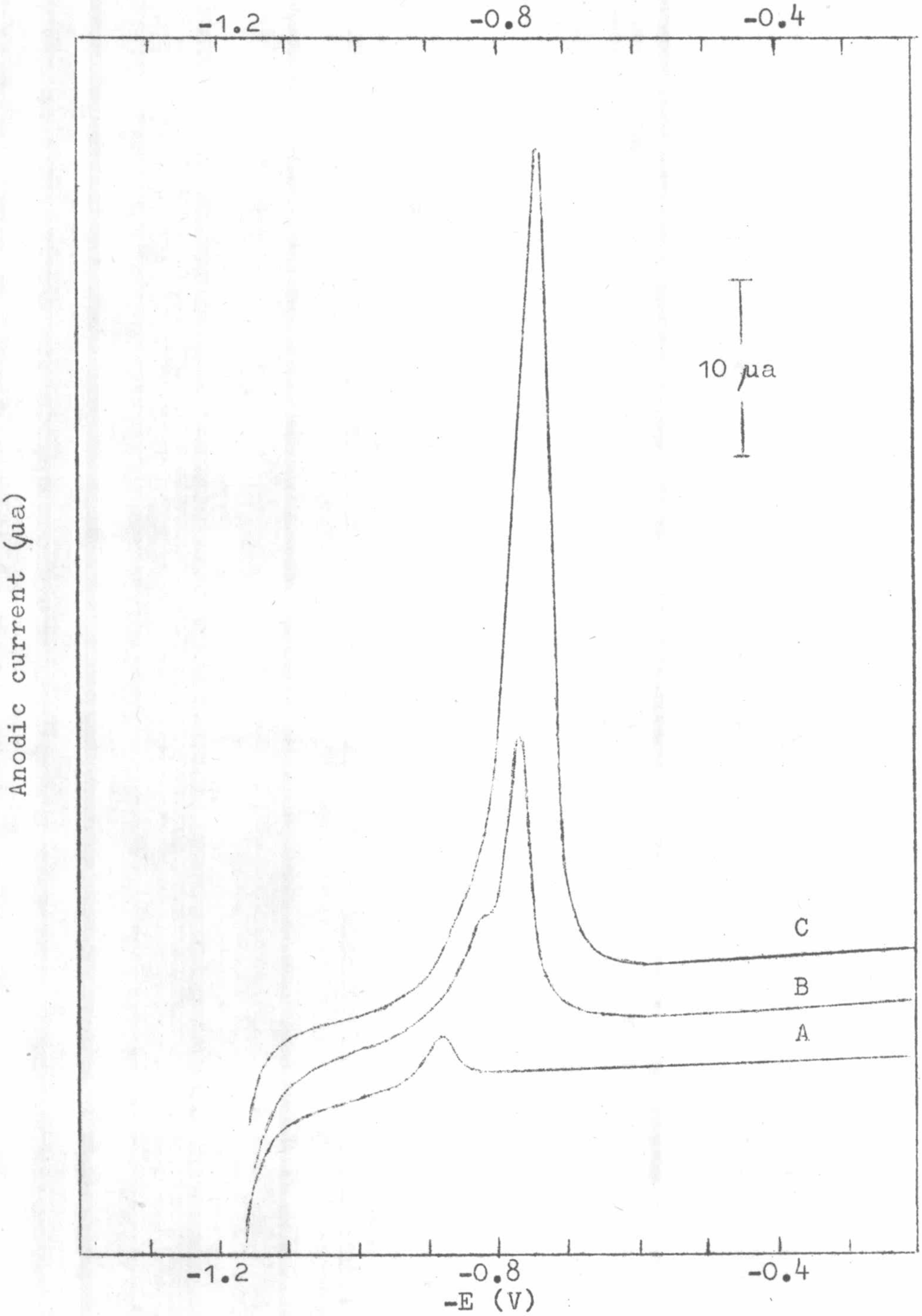

Figure 3.5 Anodic voltammogram of thallium in 0.1 M KNO_3 A) 1.00 X 10^{-5}M Tl (I), B) 2.00 X 10^{-5}M Tl (I), C) 4.00 X 10^{-5}M Tl (I) using a 5 minute deposition at -1.0 V.

Table 3.9 Conditions for electrodeposition of thallium (I) and data of anodic stripping analysis of thallium in 0.1 M KNO_3

Deposition		Conc. of Tl(I) (M)	$E_{p,a}$ (V)	$i^*_{p,a}$ (μa)	Detection limit (M)
Potential (V)	time (min)				
-1.0	3	1.00×10^{-4}	-0.66	93.25 ± 1.63	
		8.00×10^{-5}	-0.67	74.73 ± 1.82	
		6.00×10^{-5}	-0.69	61.12 ± 3.90	
		4.00×10^{-5}	-0.71	39.58 ± 2.17	
		2.00×10^{-5}	-0.76	15.83 ± 0.89	
		1.00×10^{-5}	-0.77	7.37 ± 0.29	
-1.0	10	1.00×10^{-5}	-0.73	27.04 ± 3.17	
		8.00×10^{-6}	-0.74	20.87 ± 1.84	
		6.00×10^{-6}	-0.75	16.33 ± 1.14	
		4.00×10^{-6}	-0.77	8.81 ± 1.12	
		2.00×10^{-6}	-0.80	2.51 ± 0.13	
		1.00×10^{-6}	-0.82	0.31 ± 0.02	1.00×10^{-6}

* average anodic peak current ± average deviation of more than five trials.

Table 3.10 Conditions for electrodeposition of thallium (I) and data of anodic stripping analysis of thallium in acetate buffer pH 5.0 (0.0472 M acetic acid - 0.1128 M sodium acetate)

Deposition		Conc. of Tl(I)	$E_{p,a}$	$i_{p,a}$*	Detection limit
Potential (V)	time (min)	(M)	(V)	(μa)	(M)
-1.0	3	1.00×10^{-4}	-0.66	83.28 ± 2.94	
		8.00×10^{-5}	-0.67	70.80 ± 1.50	
		6.00×10^{-5}	-0.68	52.06 ± 0.73	
		4.00×10^{-5}	-0.71	31.51 ± 3.56	
		2.00×10^{-5}	-0.76	9.85 ± 0.80	
		1.00×10^{-5}	-0.80	1.40 ± 0.15	
-1.0	10	1.00×10^{-5}	-0.70	25.20 ± 3.20	
		8.00×10^{-6}	-0.72	17.06 ± 0.94	
		6.00×10^{-6}	-0.75	12.30 ± 0.15	
		4.00×10^{-6}	-0.76	8.60 ± 0.40	
		2.00×10^{-6}	-0.78	1.98 ± 0.19	
		1.00×10^{-6}	-0.58	0.20 ± 0.01	1.00×10^{-6}

* average anodic peak current ± average deviation of more than five trials.

Figure 3.6, 3.7 and 3.8). Thus, Tl (I) is able to be determined by ASV on a 0.071 cm^2 GCE in 0.1 M KNO_3, 0.1 M KCl, and acetate buffer at pH 5.0 for the concentration of 1.00 X 10^{-6}M Tl (I) and higher.

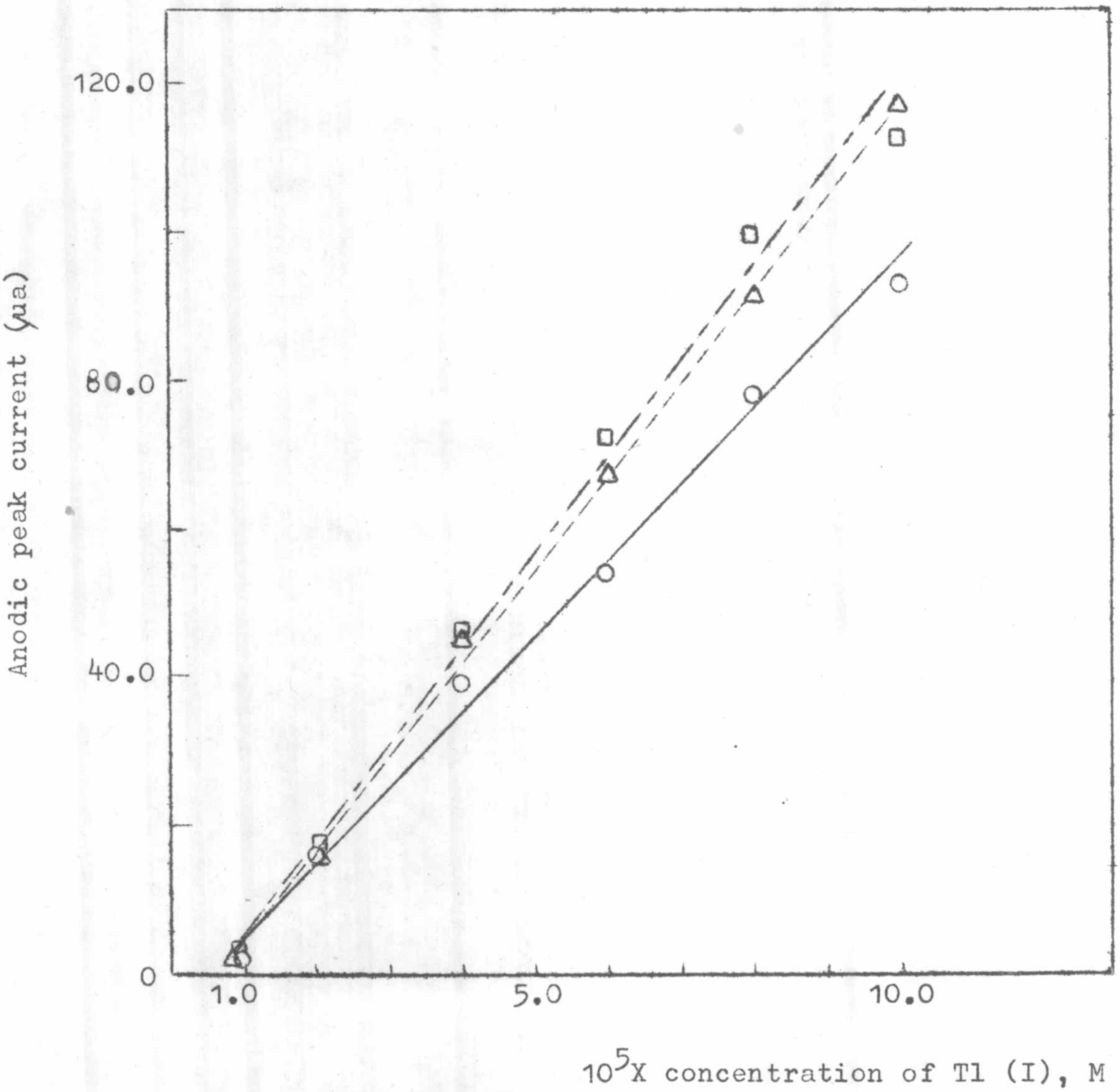

Figure 3.6 The linear dependence of anodic peak current on concentration for anodic strippimg analysis of thallium (I), using a deposition time of 5 minutes at -1.0 volt in 0.1 M KNO_3(□), 0.1 M KCl (△) and acetate buffer pH 5.0 (○).

The lines drawn are calculated least squares lines.

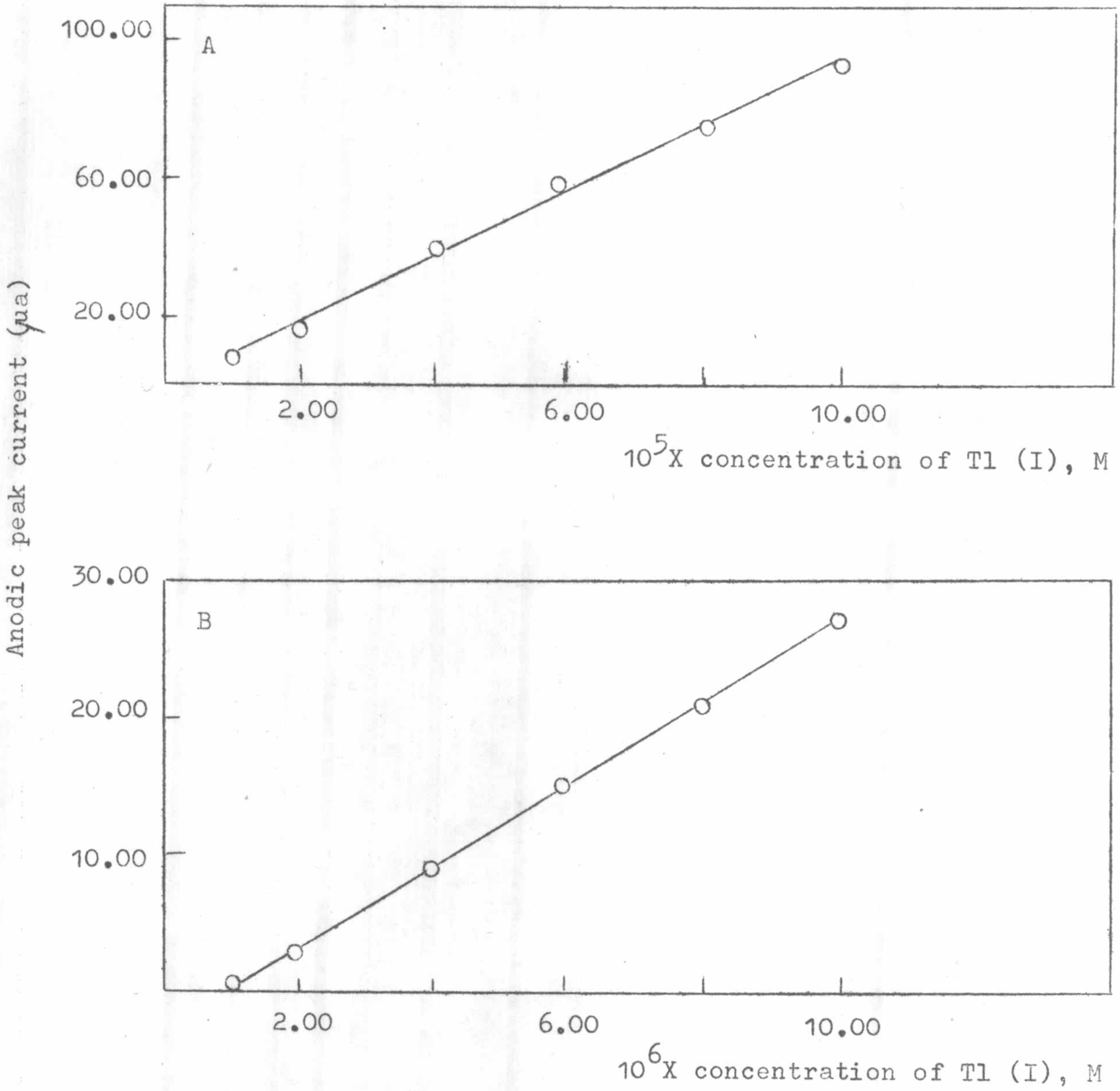

Figure 3.7 The linear dependence of anodic peak current on concentration for anodic stripping analysis of Tl (I) in 0.1 M KNO_3 using electrodeposition time of A) 3 minutes, B) 10 minutes.

The lines drawn are calculated least squares lines.

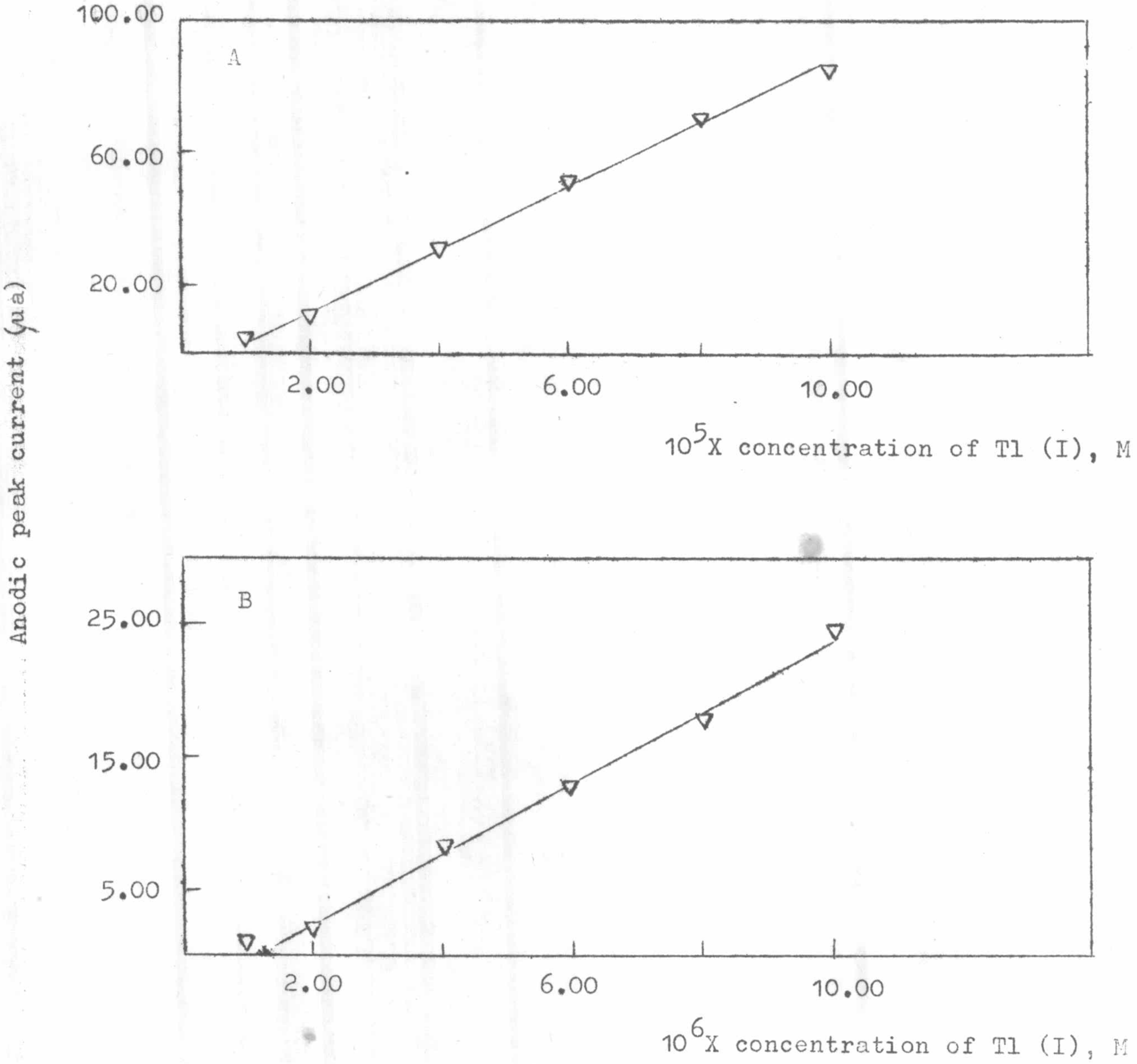

Figure 3.8 The linear dependence of anodic peak current on concentration for anodic stripping analysis of Tl (I) in acetate buffer pH 5.0 using electrodeposition time of A) 3 minutes, B) 10 minutes. The lines drawn are calculated least squares lines.