

# Voltammetric determination of platinum and rhodium in the ultratrace range

Of interest to:

General analytical laboratories; Environmental protection; Pharmaceutical industry; Biochemistry, biology, medical science; Trace analysis; Metals; Fertilizers

B 1, 2, 4, 8, 9, 10, 11

## Summary

This Bulletin describes an analytical method for the determination of traces of Pt and Rh in the ppt range (ng/kg) by stripping voltammetry. Interest in the determination of even minute quantities of platinum and rhodium in environmental materials has greatly increased in recent years. Their emission into the environment from automobile exhaust gas catalytic converters is of great interest. The same applies to the determination of platinum in body fluids and tissue samples following chemotherapeutic treatment for cancer.

Using the hanging mercury drop electrode (HMDE) and the DP (Differential Pulse) measuring technique, determination limits of approx. 0.1 ng/L Pt and 0.5 ng/L Rh can be achieved.

## Instruments and accessories

- 746 VA Trace Analyzer with 747 VA Stand or
- 757 VA Computrace
- 705 UV Digester

## Electrodes

WE Multi-Mode Electrode MME  
6.1246.020

RE Ag/AgCl/c(KCl) = 3 mol/L  
6.0728.020 + 6.1245.010

The intermediate electrolyte vessel is filled with c(KCl) = 3 mol/L (suprapur).

AE Glassy Carbon GC  
6.1241.020 + 6.1247.000

## Sample preparation

The determinations described are extremely sensitive to interference by organic substances, which is why all samples (even drinking water) must undergo digestion.

### • Water, aqueous solutions

In this case UV digestion (irradiation with UV light) has proved to be best.

10 mL sample is acidified with 10  $\mu$ L w(HCl) = 30% (suprapur) (approx. pH = 2), 50  $\mu$ L w(H<sub>2</sub>O<sub>2</sub>) = 30% (suprapur) is added and the solution irradiated in the 705 UV Digester for 1.5 h.

After cooling down the digestion solution can be used directly for the voltammetric determination.

### • Biological materials

There are two suitable digestion methods for materials with a high organic content:

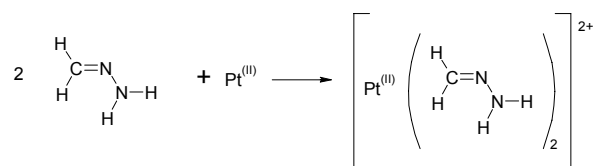
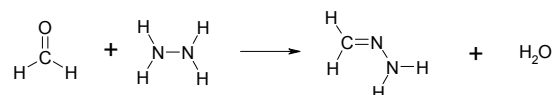
- High-pressure ashing («High-Pressure Asher», HPA)
- Microwave digestion

In both cases the sample is oxidized in sealed digestion vessels by a mixture of concentrated acids. The vessels are either heated conventionally (HPA) or by microwave irradiation.

## Method 1: Determination of Pt

### Theory

Formaldehyde and hydrazine can be condensed to form the corresponding hydrazone, which forms a complex with Pt(II):



This complex is adsorbed on the surface of the HMDE, where it reduces the hydrogen overpotential. The measured signal of the hydrogen reduction is proportional to the concentration of the Pt complex. Owing to the catalytic effect of platinum the determination is extremely sensitive.

## Reagents

All reagents used should have the highest possible degree of purity (puriss. p.a. or suprapur). Only ultrapure water should be used for preparing the solutions.

- Sulfuric acid,  $w(\text{H}_2\text{SO}_4) = 96\%$ , suprapur
- Formaldehyde solution,  $w(\text{HCHO}) = 37\%$  (CAS 50-00-0)
- Hydrazinium sulfate  $\text{N}_2\text{H}_6\text{SO}_4$ , purity 99.999% (CAS 10034-93-2)
- Pt(IV) stock solution,  $\beta[\text{Pt(IV)}] = 1 \text{ g/L}$  (commercially available)

## Ready-to-use solutions

<b>Hydrazinium sulfate solution</b>	$c(\text{N}_2\text{H}_6\text{SO}_4) = 0.1 \text{ mol/L}$ 0.13 g hydrazinium sulfate is dissolved in 10 mL ultrapure water. This solution is stable for max. 1 week.
<b>Supporting electrolyte</b>	$c(\text{H}_2\text{SO}_4) = 0.72 \text{ mol/L}$ $c(\text{HCHO}) = 6.7 \cdot 10^{-3} \text{ mol/L}$ $c(\text{N}_2\text{H}_6\text{SO}_4) = 3 \cdot 10^{-3} \text{ mol/L}$ Approx. 15 mL ultrapure water and 0.8 mL $w(\text{H}_2\text{SO}_4) = 96\%$ are mixed in a 20 mL volumetric flask. After cooling down to room temperature, 0.6 mL $c(\text{N}_2\text{H}_6\text{SO}_4) = 0.1 \text{ mol/L}$ and 10 $\mu\text{L}$ $w(\text{HCHO}) = 37\%$ are added and the solution is filled to the mark with ultrapure water. This supporting electrolyte must be freshly prepared every day.
<b>Pt(IV) standard solution</b>	$\beta[\text{Pt(IV)}] = 1 \text{ }\mu\text{g/L}$ This solution is prepared from the Pt(IV) stock solution by dilution with $c(\text{HCl}) = 0.1 \text{ mol/L}$ . Dilutions with concentrations below 1 mg/L should be freshly prepared every day.

## Analysis

### Measuring solution:

10 mL digestion solution (diluted if necessary)  
 + 1.5 mL supporting electrolyte

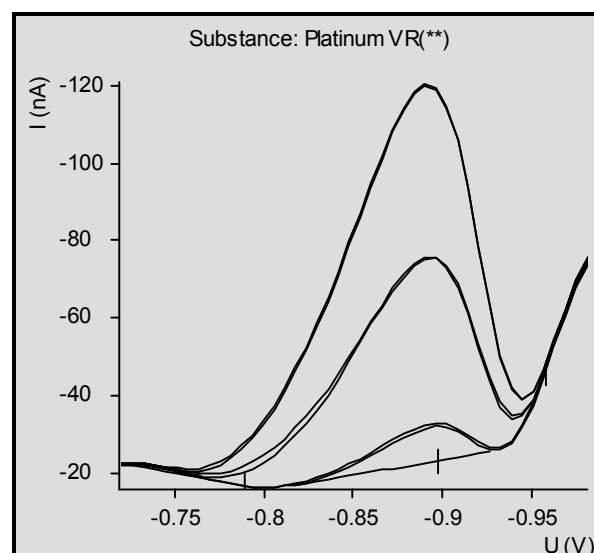
The voltammogram is recorded using the following parameters:

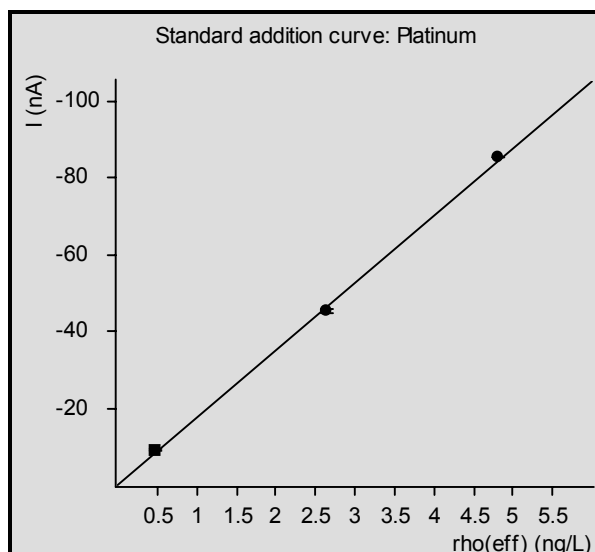
Working electrode	HMDE
Stirrer speed	2000 rpm
Mode	DP
Purge time	300 s
Addition purge time	30 s
Deposition potential	-600 mV
Deposition time	120 s
Equilibration time	10 s
Pulse amplitude	50 mV
Start potential	-600 mV
End potential	-1100 mV
Voltage step	6 mV
Voltage step time	0.3 s
Sweep rate	20 mV/s
Peak potential Pt	-880 mV

The concentration is determined by standard addition.

### Example:

#### Determination of Pt in tap water (spiked sample) after UV digestion





Sample volume: 10 mL

**Result:** 0.6 ng/L Pt

#### Remarks

- Under no circumstances should the determination be carried out with a Pt auxiliary electrode.
- A reference electrode that has already been used together with a Pt electrode should not be used.
- It is very advantageous if all vessels and electrodes are only used for this determination.
- If during the preparation of the supporting electrolyte the solution is not allowed to cool down to room temperature before the addition of the hydrazinium sulfate and formaldehyde then an inter-

ference peak will appear in the voltammogram at the peak potential of platinum.

- Pt(IV) is reduced to Pt(II) by the supporting electrolyte.
- With a deposition time of 120 s the determination limit for Pt is approx. 0.1 ng/L.
- The sensitivity of the method could not be increased by using other measuring modes (SQW and AC1).
- With a deposition time of 60 s the working range is linear up to 200 ng/L Pt.
- With higher concentrations of nitrate the Pt peak is lost in the increase of the baseline. For example, 0.16 mol/L  $\text{NO}_3^-$  reduces the recovery of 5 ppt Pt by 50%.

#### Literature

- Z. Zhao, H. Freiser  
Differential pulse polarographic determination of trace levels of platinum  
Anal. Chem. 58 (1986) 1498–1501.
- K. Hoppstock, F. Alt, K. Cammann, G. Weber  
Determination of platinum in biotic and environmental materials. Part II: A sensitive voltammetric method  
Fresenius Z. Anal. Chem. 335 (1989) 813–816.
- C. M. G. van den Berg, G. S. Jacinto  
The determination of platinum in sea water by adsorptive cathodic stripping voltammetry  
Anal. Chim. Acta. 211 (1988) 129–139.

#### Method for the determination of Pt with the 746 VA Trace Analyzer (method 1)

```

===== METROHM 746 VA TRACE ANALYZER (5.746.0101) =====
Method: AB220 Pt.mth          OPERATION SEQUENCE
Title : Determination of Platinum with DPCSV. AB220
-----

```

	Instructions	t/s	Main parameters	Auxiliary parameters
1	SMPL>M		V.fraction mL	V.total L
2	DOS>M		Soln.name electrol	V.add 1.500 mL
3	PURGE			
4	STIR	300.0	Rot.speed 2000 /min	
5	(ADD			
6	PURGE			
7	STIR	30.0	Rot.speed 2000 /min	
8	(REP			
9	SEGMENT		Segm.name DPCSV	
10	REP) 1			
11	ADD>M		Soln.name Pt Std	V.add 0.025 mL
12	ADD) 2			
13	END			

Method: AB220 Pt		SEGMENT DPCSV			
Instructions		t/s	Main parameters		Auxiliary parameters
1	OPURGE				
2	STIR	5.0	Rot.speed	2000 /min	
3	HMDE		Drop size	4	Meas.cell normal
4	DPMODE		U.ampl	-50 mV	t.meas 20.0 ms
			t.step	0.30 s	t.pulse 40.0 ms
5	MEAS	120.0	U.meas	-600 mV	
6	OSTIR	10.0			
7	FSWEEP	26.1	U.start	-600 mV	U.step 6 mV
			U.end	-1100 mV	Sweep rate 20 mV/s
8	OMEAS		U.standby	mV	
9	END				

**Full report for the determination of Pt in tap water (spiked sample) after UV digestion**

```

===== METROHM 746 VA TRACE ANALYZER (5.746.0101) =====
Determ.      : 11221602          User:          Date: 2000-11-22
Modified     : 2000-11-22 16:38:04 Run : 0          Time: 16:02:51
Sample table: -
-----
  Pos.  Ident.1/S1  Ident.2/S2  Ident.3/S3  Method.call  Sample size/S0
-----
    6    Auf221100 2
-----
Method : AB220 Pt
Title  : Determination of Platinum with DPCSV. AB220
Remark1 : 10 mL sample + 1.5 mL electrolyte
Remark2 : tap water (digestion 22.11.2000/2 pos.6)
-----
Substance : Platinum
Mass conc.: 551.8 pg/L          Mass      : 5.518 pg
MC.dev.   : 63.7 pg/L (11.5%)  Add.mass  : 25 pg
Cal.dev.  : -                  V0.sample: 10 mL
-----
      VR  U/mV  I/nA  I.mean  Std.dev.  I.delta  Comments
-----
      00 -897  -8.897 -9.055  0.2229   -        front overlapping
      01 -896  -9.212          -        front overlapping
      10 -897 -45.44 -45.10  0.4846  -36.04  front overlapping
      11 -897 -44.76          -        front overlapping
      20 -897 -84.78 -84.87  0.1349  -39.77  crit. rear ovlp.
      21 -896 -84.97          -        crit. rear ovlp.
-----
Substance  Techn.  Y.reg/offset  Slope  Nonlin.  Mean deviat.
-----
Platinum   std.add.  -8.407e-09   -17.52          1.160e-09
-----
Final results          +/- Res.dev.  %  Comments
-----
Platinum = 551.78 pg/L          63.7  11.5

```

## Method 2: Determination of Rh

### Theory

In a hydrochloric acid solution rhodium forms a complex with formaldehyde that can be adsorbed on the HMDE. The adsorbed complex reduces the hydrogen overpotential at the mercury electrode and thus catalyzes the reduction of hydrogen. The signal of the hydrogen reduction is used for the determination; its size is proportional to the concentration of the Rh complex. The catalytic effect of the rhodium explains the extreme sensitivity of the method.

### Reagents

All reagents used should have the highest possible degree of purity (puriss. p.a. or suprapur). Only ultrapure water should be used for preparing the solutions.

- Hydrochloric acid, w(HCl) = 30%, suprapur
- Formaldehyde solution, w(HCHO) = 37% (CAS: 50-00-0)
- Rh(III) stock solution,  $\beta[\text{Rh(III)}] = 1 \text{ g/L}$  (commercially available)

### Ready-to-use solutions

<b>Rh(III) standard solution</b>	$\beta[\text{Rh(III)}] = 1 \text{ } \mu\text{g/L}$ This solution is prepared from the Rh(III) stock solution by dilution with $c(\text{HCl}) = 0.1 \text{ mol/L}$ . Dilutions with concentrations below 1 mg/L should be freshly prepared every day.
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### Analysis

#### Measuring solution:

10 mL digestion solution (diluted if necessary)  
 + 200  $\mu\text{L}$  w(HCl) = 30%  
 + 10  $\mu\text{L}$  w(HCHO) = 37%

The voltammogram is recorded using the following parameters:

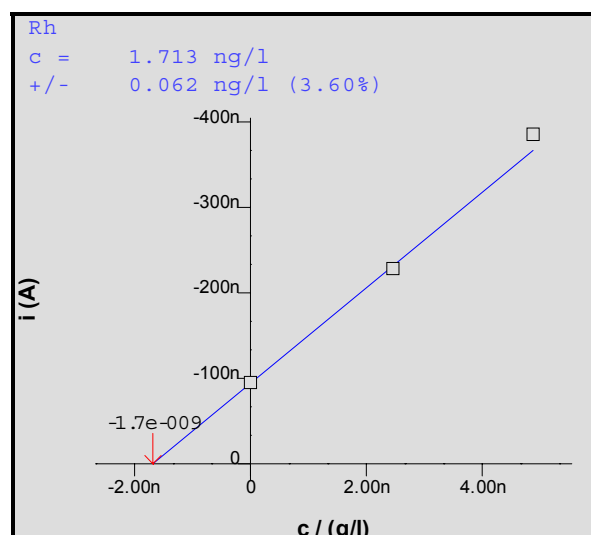
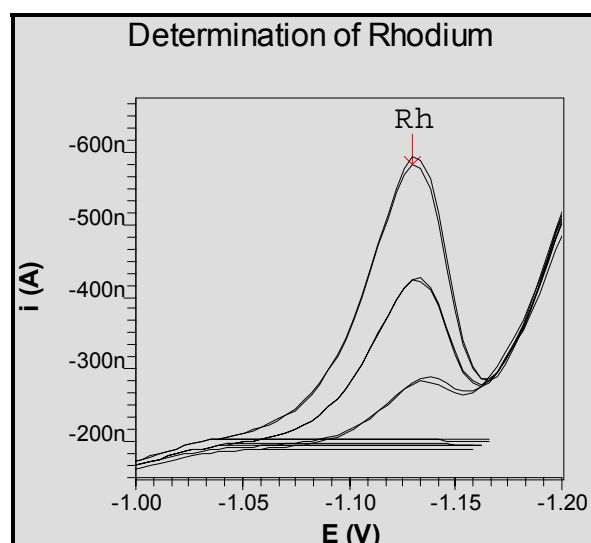
Working electrode	HMDE
Stirrer speed	2000 rpm
Mode	DP
Purge time	300
Addition purge time	30
Deposition potential	-700 mV
Deposition time	60 s
Equilibration time	10 s
Pulse amplitude	50 mV

Start potential	-900 mV
End potential	-1230 mV
Voltage step	4 mV
Voltage step time	0.3 s
Sweep rate	13.3 mV/s
Peak potential Rh	-1150 mV

The concentration is determined by standard addition.

### Example:

#### Determination of Rh in tap water (spiked sample) after UV digestion



Sample volume: 10 mL

**Result:** 1.7 ng/L Rh

### Remarks

- As the Rh peak lies in the hydrogen increase region it is recommended that only the front half of the peak is evaluated.
- With a deposition time of 120 s the determination limit for Rh is approx. 0.5 ng/L.
- With a deposition time of 60 s the working range is linear up to 500 ng/L Rh.
- The presence of nitrate does not interfere with the determination but displaces the potential of the Rh peak towards more negative values.

### Literature

- E. Helmers, N. Mergel  
 Platinum and rhodium in a polluted environment: Studying the emissions of automobile catalysts with emphasis on the application of CSV rhodium analysis  
 Fresenius J. Anal. Chem. 362 (1998) 522–528.
- C. León, H. Emons, P. Ostapczuk, K. Hoppstock  
 Simultaneous ultratrace determination of platinum and rhodium by cathodic stripping voltammetry  
 Anal. Chim. Acta. 336 (1997) 99–104.

### Method for the determination of Rh with the 746 VA Trace Analyzer (method 2)

```
===== METROHM 746 VA TRACE ANALYZER (5.746.0101) =====
Method: AB220 Rh.mth          OPERATION SEQUENCE
Title : Determination of Rhodium with DPCSV. AB220
-----
```

	Instructions	t/s	Main parameters	Auxiliary parameters
1	SMPL>M		V.fraction mL	V.total L
2	DOS>M		Soln.name	V.add 0.210 mL
3	REM		200 uL HCl (30%), 10 uL Formaldehyde (37%)	
4	PURGE			
5	STIR	300.0	Rot.speed 2000 /min	
6	(ADD			
7	PURGE			
8	STIR	30.0	Rot.speed 2000 /min	
9	(REP			
10	SEGMENT		Segm.name DPCSV	
11	REP)1			
12	ADD>M		Soln.name Rh Std	V.add 0.025 mL
13	ADD)2			
14	END			

```
Method: AB220 Rh          SEGMENT
                          DPCSV
-----
```

	Instructions	t/s	Main parameters	Auxiliary parameters
1	OPURGE			
2	STIR	5.0	Rot.speed 2000 /min	
3	HMDE		Drop size 4	Meas.cell normal
4	DPMODE		U.ampl -50 mV	t.meas 20.0 ms
			t.step 0.30 s	t.pulse 40.0 ms
5	MEAS	60.0	U.meas -700 mV	
6	OSTIR	10.0		
7	FSWEEP	25.8	U.start -900 mV	U.step 4 mV
			U.end -1230 mV	Sweep rate 13.33 mV/s
8	OMEAS		U.standby mV	
9	END			

**Full report for the determination of Rh in tap water (spiked sample) after UV digestion (757 VA Computrace)**

```

===== METROHM 757 VA COMPUTRACE (5.757.0010) =====
Determ.      : 11221804 20001122 2 9.dth
Date         : 2000-11-22           Time: 18:04:05
Modified    : 2000-11-22 18:15:14   User:
                                           Cell volume: 10.210 ml
-----
Ident                Sample volume
20001122 2 9         10.000 ml
-----
Method   : AB 220 2 Det of Rh.mth
Title    : Determination of Rhodium
Remark1  : 10 mL sample + 200 uL HCl (30 %) + 10 uL Formaldehyde
Remark2  : tap water (22.11.2000/2 pos. 9)
-----
Substance : Rh                                     Comments
Mass conc.: 1.678 ng/l
MC.dev.   : 0.060 ng/l      ( 3.60%)
Mass      : 17.134 pg
Add.mass  : 25.000 pg
-----
          VR      V      nA      i.mean  Std.Dev.  i.delta  Comments
-----
          1-1     -1.138  -96.2  -94.8   1.945
          1-2     -1.134  -93.4
          2-1     -1.130  -229.0 -229.8  1.152   -135.0
          2-2     -1.134  -230.6
          3-1     -1.130  -392.3 -386.0  8.820   -156.2
          3-2     -1.130  -379.8
-----
Substance  Calibr.      Y.reg/offset  Slope      Nonlin.      Mean deviat.
-----
          Rh      std.add.      -9.383e-008  -5.594e+001  -1.903e-009
-----
Final results                +/- Res. dev.  %      Comments
-----
          Rh =      1.713 ng/l      0.062      3.602
    
```

**Method 3: Simultaneous determination of Rh and Pt**

**Theory**

Rhodium and platinum can also be determined if they are both present in the same solution. As hydrazine interferes with the Rh determination, rhodium is first determined in hydrochloric acid solution without hydrazinium sulfate. Afterwards the hydrazinium sulfate solution and dilute sulfuric acid are added and the Pt determination is carried out.

**Reagents**

All reagents used should have the highest possible degree of purity (puriss. p.a. or suprapur). Only ultrapure water should be used for preparing the solutions.

- Hydrochloric acid, w(HCl) = 30%, suprapur
- Sulfuric acid, w(H<sub>2</sub>SO<sub>4</sub>) = 96%, suprapur
- Formaldehyde solution, w(HCHO) = 37% (CAS: 50-00-0)
- Hydrazinium sulfate N<sub>2</sub>H<sub>6</sub>SO<sub>4</sub>, purity 99.999% (CAS 10034-93-2)

- Rh(III) stock solution, β[Rh(III)] = 1 g/L (commercially available)
- Pt(IV) stock solution, β[Pt(IV)] = 1 g/L (commercially available)

**Ready-to-use solutions**

<b>Hydrazinium sulfate solution</b>	<b>c(N<sub>2</sub>H<sub>6</sub>SO<sub>4</sub>) = 0,1 mol/L</b> 0.13 g hydrazinium sulfate is dissolved in 10 mL ultrapure water. This solution is stable for max. 1 week.
<b>Sulfuric acid, dilute</b>	<b>c(H<sub>2</sub>SO<sub>4</sub>) = 2 mol/L</b> The dilute sulfuric acid is prepared from w(H <sub>2</sub> SO <sub>4</sub> ) = 96% by dilution with ultrapure water.
<b>Rh(III) and Pt(IV) standard solutions</b>	<b>β[Rh(III)] = 1 µg/L</b> <b>β[Pt(IV)] = 1 µg/L</b> These solutions are prepared from the Rh(III) or Pt(IV) stock solution by dilution with c(HCl) = 0.1 mol/L. Dilutions with concentrations below 1 mg/L should be freshly prepared every day.

## Analysis

### Measuring solution for Rh determination:

10 mL digestion solution (diluted if necessary)  
+ 200  $\mu\text{L}$  w(HCl) = 30%  
+ 10  $\mu\text{L}$  w(HCHO) = 37%

The Rh determination is carried out under the conditions given in method 2.

### Measuring solution for Pt determination:

Measuring solution from Rh determination  
+ 15  $\mu\text{L}$  c( $\text{N}_2\text{H}_6\text{SO}_4$ ) = 0.1 mol/L  
+ 0.675 mL c( $\text{H}_2\text{SO}_4$ ) = 2 mol/L

After addition of the hydrazinium sulfate solution the mixture is stirred for 60 s. The dilute sulfuric acid is then added and the platinum is determined under the conditions given in method 1.

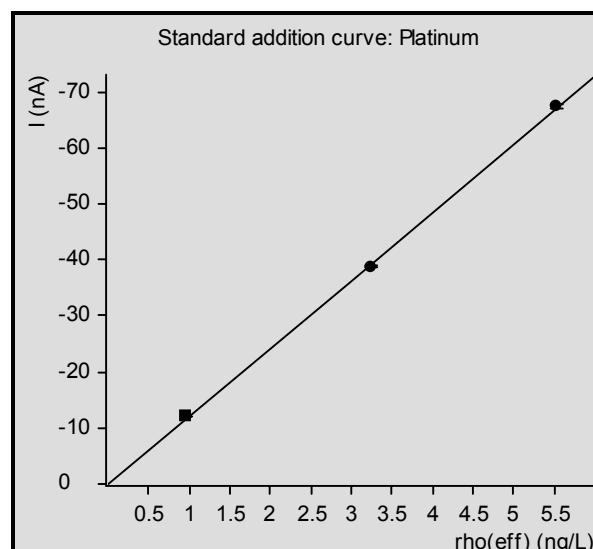
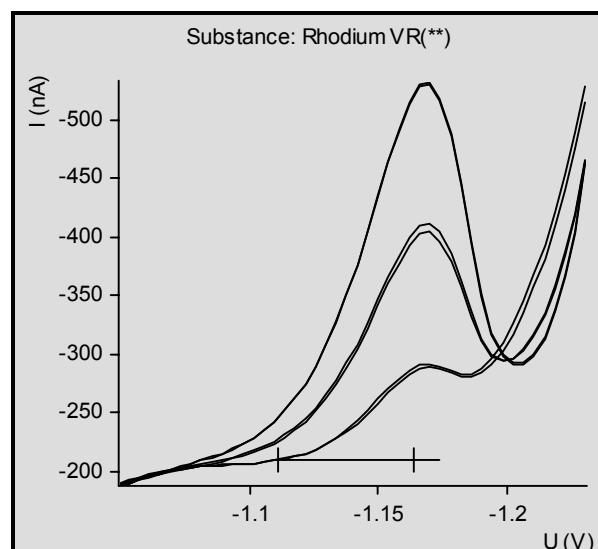
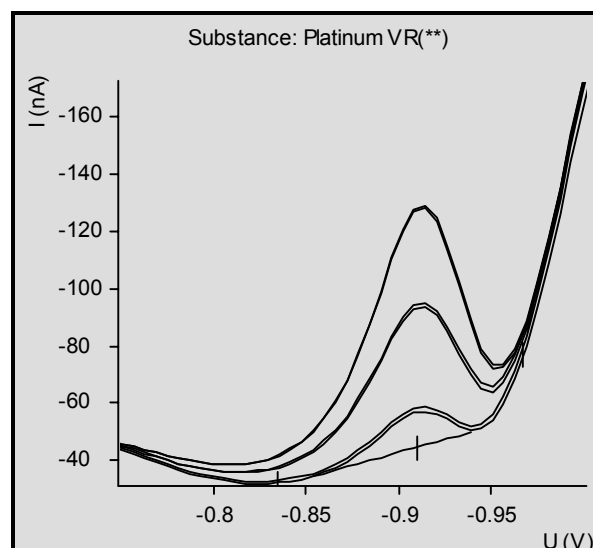
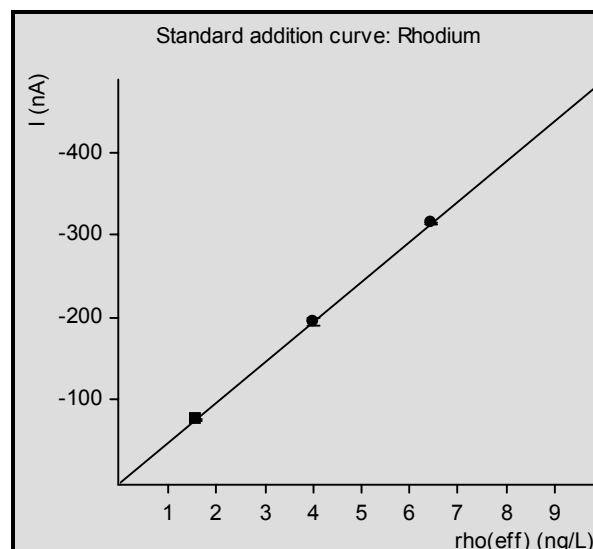
The Rh and Pt concentrations are determined by standard addition.

## Example

### Determination of Rh and Pt in tap water (spiked sample) after UV digestion

Sample volume: 10 mL

**Results:** 1.6 ng/L Rh  
1.1 ng/L Pt



### Remarks

- Under no circumstances should the determination be carried out with a Pt auxiliary electrode.
- A reference electrode that has already been used together with a Pt electrode should not be used.
- It is very advantageous if all vessels and electrodes are only used for this determination.
- In order to avoid heating the measuring solution and the enlargement of the interference peak at the Pt potential associated with this, the sulfuric acid is added in dilute form.

### Literature

- E. Helmers, N. Mergel  
 Platinum and rhodium in a polluted environment: Studying the emissions of automobile catalysts with emphasis on the application of CSV rhodium analysis  
 Fresenius J. Anal. Chem. 362 (1998) 522–528.
- C. León, H. Emons, P. Ostapczuk, K. Hoppstock  
 Simultaneous ultratrace determination of platinum and rhodium by cathodic stripping voltammetry  
 Anal. Chim. Acta. 336 (1997) 99–104.

### Method for the determination of Rh and Pt with the 746 VA Trace Analyzer (method 3)

```
===== METROHM 746 VA TRACE ANALYZER (5.746.0101) =====
Method: AB220R+P.mth          OPERATION SEQUENCE
Title : Determination of Rhodium and Platinum. AB 220
-----
```

	Instructions	t/s	Main parameters	Auxiliary parameters
1	SMPL>M		V.fraction mL	V.total L
2	DOS>M		Soln.name	V.add 0.210 mL
3	REM		+200 uL HCl (30%), 10 uL Formaldehyde (36.5%)	
4	PURGE			
5	STIR	300.0	Rot.speed 2000 /min	
6	(ADD			
7	PURGE			
8	STIR	30.0	Rot.speed 2000 /min	
9	(REP			
10	SEGMENT		Segm.name DPCSV Rh	
11	REP)1			
12	ADD>M		Soln.name Rh Std	V.add 0.025 mL
13	ADD)2			
14	STIR		Rot.speed 2000 /min	
15	DOS>M		Soln.name Hydrazin	V.add 0.015 mL
16	STIR	60.0	Rot.speed 2000 /min	
17	DOS>M		Soln.name 2M H2SO4	V.add 0.675 mL
18	PURGE	30.0		
19	(ADD			
20	PURGE			
21	STIR	30.0	Rot.speed 2000 /min	
22	(REP			
23	SEGMENT		Segm.name DPCSV Pt	
24	REP)1			
25	ADD>M		Soln.name Pt Std	V.add 0.025 mL
26	ADD)2			
27	END			

```
Method: AB220R+P          SEGMENT
                          DPCSV Rh
-----
```

	Instructions	t/s	Main parameters	Auxiliary parameters
1	0PURGE			
2	STIR	5.0	Rot.speed 2000 /min	
3	HMDE		Drop size 4	Meas.cell normal
4	DPMODE		U.ampl -50 mV	t.meas 20.0 ms
			t.step 0.30 s	t.pulse 40.0 ms
5	MEAS	60.0	U.meas -700 mV	
6	OSTIR	10.0		
7	FSWEEP	25.8	U.start -900 mV	U.step 4 mV
			U.end -1230 mV	Sweep rate 13.33 mV/s
8	OMEAS		U.standby mV	
9	END			

Method: AB220R+P		SEGMENT DPCSV Pt			
Instructions	t/s	Main parameters		Auxiliary parameters	
1	OPURGE				
2	STIR	5.0	Rot.speed	2000 /min	
3	HMDE		Drop size	4	Meas.cell normal
4	DPMODE		U.ampl	-50 mV	t.meas 20.0 ms
			t.step	0.30 s	t.pulse 40.0 ms
5	MEAS	60.0	U.meas	-600 mV	
6	OSTIR				
7	FSWEEP	26.1	U.start	-600 mV	U.step 6 mV
			U.end	-1100 mV	Sweep rate 20 mV/s
8	OMEAS		U.standby	mV	
9	END				

**Full report for the determination of Rh and Pt in tap water (spiked sample) after UV digestion**

```

===== METROHM 746 VA TRACE ANALYZER (5.746.0101) =====
Determ.      : 11221713          User:          Date: 2000-11-22
Modified     : no                Run : 0         Time: 17:13:37
Sample table: -
-----
  Pos.  Ident.1/S1  Ident.2/S2  Ident.3/S3  Method.call  Sample size/S0
-----
    8    Auf221100 2
-----
Method : AB220R+P
Title  : Determination of Rhodium and Platinum. AB 220
Remark1 : Aufschluss 22.11.2000/2 Pos.8
Remark2 : tap water
-----
Substance : Rhodium
Mass conc.: 1.600 ng/L          Mass          : 16 pg
MC.dev.   : 0.059 ng/L (3.66%) Add.mass      : 25 pg
Cal.dev.  : -                  V0.sample    : 10 mL
-----
      VR  U/mV  I/nA  I.mean  Std.dev.  I.delta  Comments
-----
      00 -1163 -75.84 -76.76   1.309    -        front overlapping
      01 -1162 -77.69 -76.76   1.309    -        front overlapping
      10 -1167 -197.2 -193.9   4.652   -117.2
      11 -1167 -190.6 -190.6   4.652   -117.2
      20 -1168 -312.6 -313.6   1.417   -119.6
      21 -1168 -314.6 -314.6   1.417   -119.6
-----
Substance : Platinum
Mass conc.: 1.062 ng/L          Mass          : 10.62 pg
MC.dev.   : 0.050 ng/L (4.7%)  Add.mass      : 25 pg
Cal.dev.  : -                  V0.sample    : 10 mL
-----
      VR  U/mV  I/nA  I.mean  Std.dev.  I.delta  Comments
-----
      00 -910 -12.01 -12.09   0.1041   -        front overlapping
      01 -910 -12.16 -12.09   0.1041   -        front overlapping
      10 -912 -38.77 -38.68   0.1339   -26.59  front overlapping
      11 -912 -38.58 -38.68   0.1339   -26.59  front overlapping
      20 -913 -66.97 -67.13   0.2241   -28.45  front overlapping
      21 -913 -67.29 -67.13   0.2241   -28.45  front overlapping
-----
Substance  Techn.      Y.reg/offset  Slope      Nonlin.      Mean deviat.
-----
Rhodium    std.add.      -7.626e-08   -48.67     -            2.673e-09
Platinum   std.add.      -1.176e-08   -12.12     -            5.902e-10
-----
Final results          +/-  Res.dev.  %      Comments
-----
Rhodium = 1.5997 ng/L    0.059  3.66
Platinum = 1.0621 ng/L 0.050  4.70
  
```