Electrochemical detection of lead (II) at bismuth/Poly(1,8-diaminonaphthalene) modified carbon paste electrode

Fatima Ezzahra Salih, Aicha Ouarzane, Mama El Rhazi *

Laboratory of Physical Chemistry & Bioorganic Chemistry, Faculty of Sciences and Technologies – BP 146, Mohammedia 20650, University Hassan II Casablanca, Morocco

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Abstract A new sensor based on carbon paste electrode modified with Poly(1,8-diaminonaphthalene) and bismuth film (Bi-Poly1,8-DAN/CPE) was prepared and characterized with cyclic voltammetry and electrochemical impedance spectroscopy. The sensor was found to exhibit an electroactivity toward the sensing of lead using square wave voltammetry in acidic medium. Various operational parameters, such as concentration of Bi(III), square wave voltammetric parameters, deposition potential and deposition time were investigated. Under the optimized conditions, a linear range was achieved over concentration range from 0.5 µg L⁻¹ to 50 µg L⁻¹, with a detection limit of 0.3 µg L⁻¹ offering a good repeatability and reproducibility. Finally, the Bi-Poly1,8-DAN/CPE was applied for the analysis of lead in water samples with satisfactory results.

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1. Introduction
Excessive levels or even small doses of very toxic metals (i.e. lead, cadmium, mercury) can cause several damages on the environment and human health. Therefore sensitive and selective methods for the detection of heavy metals especially lead have become a priority in environmental monitoring. During the last decades, different approaches have been used to develop high-performance electrochemical sensors based on bismuth film or conducting polymers (Hwang et al., 2008a,b; Kefala and Economou, 2006; Yi et al., 2012). Since the pioneering work of Wang (Wang et al., 2000), Bismuth film electrode called environmentally friendly electrode has been widely used in organic, biological and pharmaceutical analysis (Chatzitheodorou et al., 2004; de Lima and Spinelli, 2013; Jain and Sharma, 2012; Pierini et al., 2013). Detections of heavy metals especially lead using voltammetric techniques and bismuth film electrodes have been reported in some excellent reviews (Arduini et al., 2010; Baldrianova et al., 2007; Lezi et al., 2012; Švancara et al., 2010; Wang, 2005). Consequently, Bismuth has been introduced as an alternative working electrode material, and it has a property to form binary or...
multi-component alloy with some heavy metals commonly known as fused alloy, facilitating the nucleation process during deposition of heavy metal ions.

The modification of the electrode by organic conducting polymers has also been a very active area of research. Organic conducting polymers received great attention due to their potential application as electrochemical sensors (Ates and Sarac, 2009; Bai et al., 2009; Shahrokhi et al., 2015). Philips et al., demonstrated that the chelating cyano group containing polyammine derivative could be an effective electrode for ultrasensitive electrode for detection of lead and cadmium (Philips et al., 2012). The electrochemical modification of glassy carbon with electropolymerized form of 1,10-phenanthronine for voltammetric determination of cadmium was reported by Oztekin et al. (2011). The sensitivity of Poly(1,8-diaminonaphthalene) to heavy metal ions such as Ag\(^{+}\), Hg\(^{2+}\) and Cu\(^{2+}\) has been studied using electrochemical and spectroscopic methods. The ability of conducting polymer matrices to complex heavy metals was studied by different groups. It has been proved that metal ions form complexes with amino groups of the polymer (El Rhazi and Majid, 2014; Nguyen et al., 2011).

More recently, the combination of metallic ions with polymers has been investigated to improve the properties of these materials for electroanalytical purposes. Ojani et al., reported that the combination of 1,5-diaminonaphthalene and Nickel particles improves the oxidation of methanol (Ojani et al., 2008). In another study, Hathoot et al., prepared and characterized the Poly,1,5-diaminonaphthalene on the surface of carbon electrode using cyclic voltammetry. After electropolymerization, the transition metal ions of Ni (II) were incorporated to electrode using cyclic voltammetry. After electropolymerization, the electrode was cycled in 0.1 M HCl solution free of monomer. The electrode surface could be renewed by simple extrusion of a small amount of paste from the tip of the electrode and the polymer could be renewed very easily. Then, the bismuth film electrode was deposited at negative potential. For determination of lead, the Poly (1,8-DAN) was modified with in situ plated bismuth film electrode and the performance of prepared sensor was then evaluated in real water samples using square wave anodic stripping voltammetry.

2. Experimental section

2.1. Reagents and materials

The chemical reagents used in the preparation of stock solutions were of analytical reagent grade. 1,8-Diaminonaphthalene (1,8-DAN) was obtained from Sigma Aldrich. All solutions were diluted by distilled water. Supporting electrolyte was solution of hydrochloric acid. Bismuth Stock solution of 100 mg L\(^{-1}\) was prepared from Bi(NO\(_3\))\(_3\)·5H\(_2\)O (Sigma Aldrich), whereas Pb(NO\(_3\))\(_2\) (Riedel–Dehaen) was employed in the preparation of metal-ion stock solution with concentration of 100 mg L\(^{-1}\).

2.2. Instrumentation

Voltammetric measurements (cyclic voltammetry (CV), square wave voltammetry (SWV)) and Electrochemical Impedance Spectroscopy (EIS) were performed using AUTOLAB PGSTAT302 N (EcoChemie, Utrecht, Netherlands) Potentiostat/Galvanostat controlled by GPES 4.9 software. The three-electrode system configuration includes a carbon paste as the working electrode, saturated calomel electrode (SCE) as the reference electrode, and platinum disk as the counter electrode. The pH was adjusted by addition of NaOH or HCl solution using a Fisher Scientific Accumet AB15 Basic pH meter.

2.3. Preparation of working electrode

A 1,8-Diaminonaphthalene doped carbon paste electrode (1,8-DAN/CPE) was fabricated as follows: 1% (w/w) of 1,8-DAN dissolved in a small quantity of acetonitrile, thoroughly homogenizing with 1 g graphite powder and 30% (w/w) paraffin oil using a mortar and pestle. The paste mixture was packed into electrode cavity 2 mm (Teflon-PTFE tube, \(\phi = 3\) mm) and electrical contact was established with a copper rod. The surface of the 1,8-DAN/CPE was polished on a piece of white paper. The bare carbon paste electrode (CPE) was fabricated with the same way without addition of the monomer. The Bi-Poly,1,8-DAN/CPE and BiF-CPE were prepared by in situ plating bismuth in the detection step.

2.4. Procedures

Electropolymerization was performed at a constant potential of 0.7 V (vs. SCE) for 80 s in 0.1 M HCl solution. Following the polymerization, the electrode was cycled in 0.1 M HCl solution free of monomer for five scans until a stable voltammogram was obtained. The conditions employed will be reported in the discussion.

In square wave anodic stripping voltammetric (SWASV) measurements, the modified electrode by Poly,1,8-DAN was dipped into 0.1 M HCl solution containing 500 \(\mu\)g L\(^{-1}\) Bi (III) and predetermined concentration of target Pb(II). A deposition potential of \(-1\) V (vs. SCE) and a deposition time of 120 s were applied to the working electrode under stirring conditions. The stirring was stopped and after 10 s equilibration time, the square wave anodic stripping voltammograms (SWASV) were recorded between \(-0.7\) and \(-0.3\) V (with a step increment of 5 mV and amplitude of 50 mV). For repetitive
measurements, the electrode surfaces were cleaned after each measurement at 0.3 V (vs. SCE) for 30 s with continuous stirring to remove the residual metals on the electrodes prior to the next measurement.

3. Results and discussion

3.1. Electropolymerization of the polydiaminonaphthalene on carbon paste electrode

The synthesis and characterization of Poly1,8-DAN were investigated using potentiostatic mode and cyclic voltammetry. The oxidation potential of DAN is an important parameter for the electropolymerization, and it can be determined easily on the basis of the first scan of cyclic voltammogram during the electropolymerization. Since it is well known, that a well-defined anodic peak could be observed at 0.6 V (vs. SCE) for the first scan during electropolymerization of dianiononaphthalene as described elsewhere (Majid et al., 2003), the electropolymerization of Poly1,8-DAN was carried out in 0.1 M HCl solution at a constant potential of +0.7 V (vs. SCE) for 80 s. Following the polymerization, the electrode was cycled in 0.1 M HCl solution at a constant potential of +0.7 V (vs. SCE) for the first scan during electropolymerization of diaminonaphthalene. The structure of formed polymer was reported with details in the literature (El Rhazi and Majid, 2014; Lee et al., 1992; Oyama et al., 1989) using anodic oxidation in both acidic and acetonitrile solutions.

3.2. Electrochemical behavior of the Poly1,8-DAN modified carbon paste electrode

Cyclic voltammetry was employed to investigate the electrochemical behavior on the CPE and Poly1,8-DAN/CPE in a 1.0 mM in [Fe (CN)₆]³⁻/⁴⁻ solution. Fig. 2 illustrates the responses obtained by cyclic voltammetry between −0.1 and +0.7 V at CPE (a) and Poly1,8-DAN/CPE (b). At CPE, a weak redox peak response was observed with ΔEp equal to 302 mV (vs. SCE). While at Poly1,8-DAN/CPE, the redox peak separation was found to be small 137 mV (vs. SCE) indicating a better electrochemical reversible behavior on Poly1,8-DAN/CPE. The redox currents responses of [Fe (CN)₆]³⁻/⁴⁻ at Poly1,8-DAN/CPE were also higher (Ipa = 243.04 µA et Ip₄ = −265.28 µA) than CPE which implied that the electron transfer rate at Poly1,8-DAN/CPE was significantly improved.

3.3. Electrochemical impedance spectroscopy

It is well known that the Electrochemical impedance spectroscopy (EIS) technique is a powerful technique to characterize the electrochemical process that occurs at the electrode/solution interface. Therefore, the electrochemical properties of bare and modified electrode were evaluated by studying redox behavior of [Fe (CN)₆]³⁻/⁴⁻ couple using EIS techniques. The impedance measurements were performed in the presence of 1.0 mM [Fe (CN)₆]³⁻/⁴⁻ in 0.1 M KCl solution at scanning frequency from 0.05 to 10,000 Hz. Fig. 3 shows the EIS diagrams of the CPE and Poly1,8-DAN/CPE. The Nyquist plot of impedance spectra includes a semicircle portion at higher frequencies corresponding to the electron transfer limited process. The charge transfer resistance (Rct) is known as a useful parameter reflecting the facility of electrode reaction, which can be measured by EIS from the semicircle diameter in the Nyquist plots (Yang and Li, 2005). The EIS tests have confirmed the conclusions deduced from the above CV experiments. The obtained values of charge transfer resistance (Rct) were 106.2 KΩ, 3.67 KΩ and the constant phase element was 16.60 µF cm⁻² and 209.54 µF cm⁻² for CPE and Poly1,8-DAN/CPE, respectively, suggesting that the surface of the Poly1,8-DAN/CPE exhibits lower electron-transfer resistance and increases the electron transfer rate.

![Figure 1](image1.png)  
**Figure 1** Cyclic voltammograms following the potentiostatic polymerization mode of Poly1,8-DAN/CPE recorded at room temperature in 0.1 M HCl solution at scan rate of 50 mV s⁻¹.

![Figure 2](image2.png)  
**Figure 2** Comparison of the cyclic voltammetric behavior at modified electrode in 1.0 mM K₃[Fe(CN)₆]/K₄[Fe(CN)₆]+0.1 M KCl solution, (a) CPE, (b) Poly1,8-DAN/CPE.
3.4. Square-wave anodic stripping voltammetric analysis of Pb (II)

After the characterization of the electrodes, the ability of such electrode to detect lead was investigated. Preliminary experiments were carried out on different electrodes. CPE, Poly1,8-DAN/CPE were dipped in solution containing 100 \( \mu \text{g} \cdot \text{L}^{-1} \) of Pb(II) with or without 1000 \( \mu \text{g} \cdot \text{L}^{-1} \) bismuth concentration. The comparison between the square wave anodic stripping voltammetric responses on a BiF-CPE (solid line), Bi-Poly1,8-DAN/CPE (dotted line) and Poly1,8-DAN/CPE (dash line) is shown in Fig. 4, indicated that the sensitivity was higher on the Bi-Poly1,8-DAN/CPE. The results demonstrated that the peak height of Pb(II) has 20% of improvement on the Bi-Poly1,8-DAN/CPE over the BiF-CPE. Similar results have been observed by Cao et al. (2008) at bismuth-modified zeolite doped carbon paste electrode against BiF-CPE and Luo et al., at bismuth-modified multwall carbon nanotubes doped carbon paste electrode (Luo et al., 2013). A considerable difference was observed between Poly1,8-DAN/CPE with and without bismuth film. Furthermore, the Bi-Poly1,8-DAN/CPE showed good reproducibility of stripping current of Pb(II).

The interaction mechanism of formed Poly1,8-DAN with lead ions can be explained by the complex formation between lead, bismuth and diaminonaphthalene (Mariame et al., 2009). Moreover, the enhanced stripping response at the modified electrode was also attributed to the fact that during the deposition step, the bismuth form “fused alloys” with lead making him more readily to be reduced. The combination of bismuth film with polymer improves the SWASV response of lead as reported by different authors (Kefala et al., 2004; Xu et al., 2008; Yang et al., 2014).

3.5. Effect of experimental variables

3.5.1. Effect of the concentrations of Bi(III)

Stripping performance of the Bi-Poly1,8-DAN/CPE was also studied with respect to the dependence of the electrode response for 50 \( \mu \text{g} \cdot \text{L}^{-1} \) of Pb(II) on the concentration of bismuth ions in the measurement solution. The effect of the concentration of the Bi(III) was examined in the range from 50 to 1000 \( \mu \text{g} \cdot \text{L}^{-1} \), with potential and deposition time of −1 V (vs. SCE) and 120 s, respectively. From Fig. 5, it is evident that even at low concentration ([Bi(III)] = 50 \( \mu \text{g} \cdot \text{L}^{-1} \)), the response of the Bi-Poly1,8-DAN/CPE toward Pb(II) was very sensitive. As the concentration of Bi(III) increased, the peak currents of Pb(II) attained a maximum value at about 250–500 \( \mu \text{g} \cdot \text{L}^{-1} \) Bi(III) and then decreased at higher concentrations. The Bi(III)/metal ion concentration ratio in the 1–10 range was adequate on bismuth film-plated CPEs as reported by Baldrianova et al.
In general the Bi concentration 10-fold the concentration of metal was the optimum for the thickness of bismuth film, and this result is consistent with previous report on bismuth film-plated CPEs (Svancara et al., 2006). Therefore, the Bi(III) concentration of 500 µg L^{-1} was selected for the rest of this work.

3.5.2. Optimization of SWV conditions

The influence of square-wave voltammetry parameters was also explored to find the optimal values of amplitude, frequency and step increment that implies a good Pb signals. First, the amplitude was varied in the range of 10–100 mV, fixing the frequency at 25 Hz. The peak current of lead increased with increasing amplitude up to 50 mV. At amplitude more than 60 mV, deformation of the peaks of bismuth and lead was observed with significant increase in peaks width. Therefore, 50 mV was chosen as the square-wave amplitude. The potential step increment together with the frequency defines the effective scan rate. The frequency was varied in the range of 10–100 Hz and the responses for lead increased with frequency in this range. No deformation in the voltammetric shape of lead oxidation and any significant reduction in peak current were observed. By fixing amplitude of 50 mV and a frequency of 50 Hz, the effect of potential step increment was studied, in the range of 1–10 mV. For potential steps lesser than 7 mV, the current peak increased in height and the peak current decreased slowly for potential steps greater than 8 mV. Hence, a frequency of 50 Hz and 5 mV potential step increment were chosen. Therefore, high and reproducible signals of Pb(II) were obtained with these parameters, the result seems to be similar compared to those found by Dimovasilis and Prodromidis (Dimovasilis and Prodromidis, 2013) using a bismuth-modified (3-mercaptopyrrol) trimethoxysilane (MPTMS).

Figure 5 The effect of the Bi(III) concentrations on the stripping currents of Pb(II) at a Bi-Poly1,8-DAN/CPE. The Bi(III) concentration varies from 50 to 1000 µg L^{-1} range. Other conditions as in Fig. 4.

3.5.3. Effect of the deposition potential and the preconcentration time

The influence of the deposition potentials on metal stripping signal was studied with 50 µg L^{-1} of Pb(II) with deposition time of 120 s in the range from −0.8 up to −1.4 V. The results showed that the stripping currents of Pb(II) moderately increased when the accumulation potential shifted from −0.8 to −1.1 V. When the deposition potential applied become more negative than −1.1 V (vs. SCE) (Fig. 6), the peak currents of Pb(II) and Bi become poor and we observe the appearance of bubbles on the electrode surface because hydrogen evolution is beginning to be significant at such negative potential as reported elsewhere (Kokkinos and Economou, 2011). The hydrogen bubbles might damage the metal alloys deposited on the electrode surface and lead to decrease in current signals at very negative potentials. Consequently, −1 V (vs. SCE) was selected for the following experiments.

The preconcentration time was studied in the range 30–300 s for solution containing 50 µg L^{-1} of Pb(II) in HCl 0.1 M solution. The stripping currents of Pb(II) increased up to 210 s, after this deposition time the peak current decreased slowly as shown in Fig. 7.

Figure 6 The effect of deposition potential on the stripping currents of 50 µg L^{-1} Pb(II) at the Bi-Poly1,8 DAN/CPE in 0.1 mol L^{-1} 0.1 M HCl solution containing 500 µg L^{-1} Bi(III).

Figure 7 The effect of deposition time on the stripping currents of 50 µg L^{-1} Pb(II) at the Bi-Poly1,8 DAN/CPE in 0.1 mol L^{-1} 0.1 M HCl solution containing 500 µg L^{-1} Bi(III).
3.6. Calibration

Under the optimized experiment conditions, the calibration curve for the determination of Pb(II) in HCl 0.1 M solution on the Bi-Poly1,8-DAN/CPE was achieved by SWASV analysis with a preconcentration time of 120 s. The resulting stripping voltammograms for different concentrations of lead are illustrated in Fig. 8. The linear regression equation was

$$\text{Ip} = 0.165 \times \text{C}_{\text{Pb}} - 0.086$$

with a high correlation coefficient of 0.9986 in the concentration range comprised between 0.5 \(\mu\text{g L}^{-1}\) and 50 \(\mu\text{g L}^{-1}\) for Pb(II). The standard deviation of the mean value for 10 voltammograms of the blank and, the slope from the calibration curve were used to determine the limit of detection (LOD) according to IUPAC recommendations (Committee and others, 1987; Miller and Miller, 2005). Then, the determinate limit of detection (LOD) for Pb(II) was 0.3 \(\mu\text{g L}^{-1}\). The obtained value exhibited a comparable and sometimes better LOD compared to some Bi modified electrodes published in the literature (see Table 1). The repeatability of the modified electrode was performed with the same electrode in a solution containing 50 \(\mu\text{g L}^{-1}\) Pb(II) with 500 \(\mu\text{g L}^{-1}\) Bi(III). The relative standard deviation (R.S. D.) of five replicates samples was 4.32%. The reproducibility of the method was also evaluated by preparing five modified electrodes at different days using the same procedure. The RSD value calculated performing the determination of 50 \(\mu\text{g L}^{-1}\) Pb(II) by SWASV was 4.6%.

![Figure 8](image-url) SWASVs for different concentrations of Pb(II) on in situ deposited Bi-poly1,8-DAN/CPE in the presence of 500 \(\mu\text{g L}^{-1}\) Bi(III). From bottom to top 0.5, 1, 5, 10, 20, 30, 40 and 50 \(\mu\text{g L}^{-1}\) Pb(II), Supporting electrolyte 0.1 M HCl solution, deposition potential –1 V, deposition time 120 s, amplitude 50 mV, increment potential 5 mV, quiet time 10 s. (Inset) the calibration curve of Pb(II). Results are presented with error bar of triplicate experiments.

<table>
<thead>
<tr>
<th>Substrate electrode</th>
<th>Technique</th>
<th>Potential deposition (V)</th>
<th>Temps deposition (s)</th>
<th>Detection limit ((\mu\text{g L}^{-1}))</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bi/Nafion/OPPy–MES/GCE</td>
<td>SWV</td>
<td>–1.2</td>
<td>300</td>
<td>0.03</td>
<td>(Chen et al., 2014)</td>
</tr>
<tr>
<td>GCE-MWCNT/poly(PCV)/Bi</td>
<td>DPASV</td>
<td>–1.3</td>
<td>420</td>
<td>0.40</td>
<td>(Chamjangali et al., 2015)</td>
</tr>
<tr>
<td>ShF-CPE</td>
<td>ASV</td>
<td>–1.2</td>
<td>120</td>
<td>0.2</td>
<td>(Tesarova et al., 2009)</td>
</tr>
<tr>
<td>MMT/BiCE</td>
<td>SWASV</td>
<td>–1.2</td>
<td>120</td>
<td>0.2</td>
<td>(Luo et al., 2010)</td>
</tr>
<tr>
<td>Pt/MWCNT/P1,5-DAN electrode</td>
<td>SWASV</td>
<td>–1.2</td>
<td>420</td>
<td>2.1</td>
<td>(Yu et al., 2015)</td>
</tr>
<tr>
<td>BiOC/MWNT-GCE</td>
<td>SWASV</td>
<td>–1.2</td>
<td>120</td>
<td>0.57</td>
<td>(Cerovac et al., 2015)</td>
</tr>
<tr>
<td>GCE/Bi-xerogel/Nafion</td>
<td>SWASV</td>
<td>–1.2</td>
<td>240</td>
<td>1.3</td>
<td>(Dimovasilis and Prodromidis, 2013)</td>
</tr>
<tr>
<td>Bi/Au–GN–Cys/GCE</td>
<td>SWASV</td>
<td>–1.2</td>
<td>800</td>
<td>0.05</td>
<td>(Zhu et al., 2014)</td>
</tr>
<tr>
<td>Bi/CPE</td>
<td>SWASV</td>
<td>–1.2</td>
<td>300</td>
<td>0.9</td>
<td>(Hoćević et al., 2005)</td>
</tr>
<tr>
<td>Porous antimony film electrode</td>
<td>ASV</td>
<td>–1.2</td>
<td>100</td>
<td>0.5</td>
<td>(Urbanová et al., 2010)</td>
</tr>
</tbody>
</table>


SWASV: square wave anodic stripping voltammetry, SWV: square wave voltammetry, DPASV: differential pulse anodic stripping voltammetry.
Table 2  Determination of Pb(II) in real samples: tap water and well water.

<table>
<thead>
<tr>
<th></th>
<th>Original µg L⁻¹</th>
<th>Added µg L⁻¹</th>
<th>Found µg L⁻¹</th>
<th>Recovery (%)</th>
<th>R.S.D. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>ND</td>
<td>5</td>
<td>5.01</td>
<td>100.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Well</td>
<td>ND</td>
<td>10</td>
<td>10.9</td>
<td>109.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Tap</td>
<td>ND</td>
<td>5</td>
<td>5.34</td>
<td>106.9</td>
<td>4.4</td>
</tr>
<tr>
<td>Water</td>
<td>ND</td>
<td>10</td>
<td>10.1</td>
<td>100.7</td>
<td>3.9</td>
</tr>
</tbody>
</table>

ND: Not detected.

3.7. Interference study

The interferences from other metal ions were investigated, which can compete and codeposit with Pb(II) at the active sites on the electrode surface. The Cu(II) and Pb(II) have a high interfering substance, which can affect the stripping currents of the bismuth electrodes. Due to the competition between bismuth and copper, the presence of Cu(II) affected greatly the Pb(II) peak which was evident even at a twofold concentration of Cu(II) over Pb(II). This is probably related to the fact that bismuth and copper have nearly same potential and that copper forms a stable complex with poly(1,8-DAN). This interference was alleviated by the addition of 0.1 mM of potassium ferrocyanide ions that form a stable complex with Cu(II), then peak lead recovered its original level and even higher (Hwang et al., 2008b). Other metals such as Cd(II), Zn(II), Fe(II), even at a ten-fold excess over Pb(II) did not affect the stripping peak of Pb(II).

3.8. Application

In order to evaluate the performance of Bi-Poly1,8-DAN/CPE, the determination of Pb (II) was carried out in two real samples from our local environment, well and tap water. The water samples were collected and adjusted to pH < 2 without any other pretreatment. No lead traces were found using the proposed procedure and under the optimized conditions. Then, the standard addition method was used and known amounts of lead were spiked to the water samples in triplicate (n = 3) according the SWASV procedure described in experimental section. Table 2 summarizes the recoveries of the results obtained for two replicate determinations of 5 µg L⁻¹ and 10 µg L⁻¹ in tap water and well water. The results given in Table 2 indicate good recoveries between 100% and 109%. The good values observed in the recovery procedure show that the proposed method is suitable for the determination of Pb(II) in real water samples.

4. Conclusion

In this work, we have shown the advantageous features of poly(1,8-DAN) modified carbon paste electrode combined to the bismuth film. A novel electrode has been proposed which is rapid, simple, easy to prepare compared with other reported methods. The possibility of the Bi-Poly1,8-DAN/CPE electrode for the determination of Pb(II) has been investigated using SWASV. The Bi-Poly1,8-DAN/CPE electrode exhibited better results compared to commonly used BiF-CP and Poly1,8-DAN/CPE electrodes due to the conducting polymer formed at the surface of the electrode and bismuth film advantage. The sensor has been successfully applied to the determination of lead ions in real water samples.

References


