

Based on Electrochemical Technology Heavy Metal Ion Detection Technology Research Progress

Hailan Shi^{1,2,3,4,5}, Zhaorong Zhang^{1,2,3,4,5}

¹Shaanxi Provincial Land Engineering Construction Group Co., Ltd. Xi'an 710075, China;

²Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd. Xi'an 710021, China;

³Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natrual Resource Xi'an 710021, China;

⁴Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an 710021, China;

⁵Land Engineering Technology Innovation Center, Ministry of Natural Resources, Xi'an 710021, China.

Abstract

The rapid measurement technology of heavy metal ions is an important research aspect in environmental monitoring, food and biomedical engineering detection related fields. This article summarizes the principles of microelectrodes applied to electrochemical technology and the principle of heavy metal ion detection based on electrochemical technology, and first analyzes the application of electrochemical technology in detection tools such as biosensors (microbial sensors) or data acquisition devices Circumstances; then combined with the development status of electrochemical technology, the development of heavy metal ion detection technology in different monitoring fields was reviewed in detail, and finally, its research development direction and prospects were dynamically analyzed and prospected.

Keywords

Heavy Metals; Electrochemistry; Sensors; Microelectrodes.

1. Introduction

Electroanalytical chemistry is a recognized fast, sensitive and accurate micro and trace analysis method in chemical composition analysis. The surface and interface electroanalytical chemistry developed in the past ten years has made electroanalytical chemistry among the high-tech fields [1-2], which has also promoted the development of electroanalytical chemistry and the development of materials, environment, medicine and biology. application. On the other hand, due to the increasing mining, smelting, processing and commercial manufacturing of heavy metals by humans, many heavy metals such as lead, mercury, cadmium, and cobalt have entered the atmosphere, water, and soil environment, which has caused serious environmental pollution [3-4]. This article is based on summarizing and explaining the principle of microelectrode applied to electrochemical technology and the principle of heavy metal ion detection based on electrochemical technology; combined with the development status of electrochemical technology, the development of heavy metal ion detection technology for its application in different monitoring fields A detailed review is given, and a dynamic analysis and research outlook are made for its development direction.

2. The principle and application of heavy metal ion detection based on electrochemical technology

Electrochemical analysis is the earliest instrumental analysis technology developed. It determines the composition and concentration of substances in solution according to their electrochemical properties and their changes [2,4]. Electrochemical analysis methods for the detection of heavy metals mainly include polarography, voltammetry and ion selective electrode methods.

Both polarography and voltammetry are a type of analysis method to study the current-potential relationship, but the electrodes used are different. The ion selective electrode method is a kind of electrochemical method that measures the ion activity by measuring the electrode potential. The potential of the ion selective electrode has a linear relationship with the logarithm of the corresponding ion activity in the solution. The instrument and equipment required by the ion selective electrode are portable and cheap, the analysis operation is simple and fast, the measurement linear range is wide, the selectivity and sensitivity are high, the color and turbidity do not affect the determination, and the station can be used for the analysis of some harmful substances in rivers, lakes and seas. [1,3]

The heavy metal ion detection technology based on electrochemical technology not only has high sensitivity, fast analysis speed, and can separate multiple ions at the same time, but also can convert some non-ionic substances into ionic substances for determination. Therefore, it is used in environmental chemistry and food chemistry, Chemical, electronics, biomedicine, new materials and many other fields have been widely used.

In addition, the heavy metal ion detection technology based on electrochemical technology is also used in detection tools such as biosensors (microbial sensors) or data acquisition devices. When they are fixed on the bioreceptor, the biomolecules and target molecules will be identified. The biochemical reaction is accompanied by a series of changes in physical properties that can be captured by the transducer, such as substance content, ionic strength, pH, gas generation, enthalpy, light and color changes, etc.

3. Development trend analysis of heavy metal ion detection technology based on electrochemical technology

The following is a dynamic development analysis of the most commonly used QCM application in heavy metal detection. QCM has the advantages of high sensitivity, small size, simple equipment, simple operation, low detection cost, and real-time online detection. It is used for the detection of various inorganic or organic small molecules (ions). It has also been extensively studied in the detection of heavy metal ions. These studies are mainly based on the adsorption of metal ions on the membrane modified QCM electrode to achieve detection [5,6]. Hunte and Price modified QCM with 4- (3-aminopropyl) morpholine-modified poly (glycidylmethacrylate-vinylpyrrolidone) copolymer membrane to detect heavy gold ions, and found that the sensor has a certain selectivity for Cu^{2+} and Ni^{2+} in the first group of transition metals, The minimum can be measured to 0.1 ppm. Jane combines QCM technology with ion chromatography technology, and uses QCM as a detector to detect various anions and cations. Ng.SC et al. modified poly [3-(6-hydroxyhexyl) thiophene] and poly (3-octane-2,2-dithiophene) LB membranes on the QCM electrode to detect Hg^{2+} , and found that the cations are in addition to Ag^+ In addition, except for Br^- , I^- , $\text{Cr}_2\text{O}_4^{2-}$ ions that can form precipitates or complexes with mercury, other ions have relatively little interference in their detection, thus achieving selective detection of Hg^{2+} to a certain extent. The range is: 0.1-100 ppm. Matthew T et al. coated the QCM electrode with N-[(3-trimethoxysilyl) propyl] ethylenediamine-triacetic acid modified silicon particles, and detected the separation and detection of Pb^{2+} and Ag^+ in the solution through the

adsorption of metal ions on the particles. The adsorption kinetics of the two ions on the particles are also studied. Gomes et al. combined flow injection analysis and QCM technology for the detection of inorganic mercury, and improved the detection sensitivity by optimizing experimental conditions such as the concentration of the acid solution, the circulation time, the flow rate of the sample carrier, and the flow rate of the reducing agent. The detection limit reached 47 µg /L. In addition, there are also reports in the literature that the EQCM (Electrochemical Quartz Microbalance) constructed by combining QCM with an electrochemical device detects Pd(II) ions in the solution. Although the detection limit of this method is not ideal, only 0.0156 mM, However, compared with the ultraviolet-visible spectrophotometric method, it has the advantages of not requiring the addition of color reagents and separation and enrichment; compared with ICP-MS and AAS, this method has the advantages of low detection cost, cheap equipment, and real-time online detection.

4. Research and development prospects

Through the previous review of the research and development status, it can be seen that the future development requires a combination of possible nanotechnology and QCM sensing technology for heavy metal ion detection methods. In order to promote the use of this method, there are still the following This aspect requires further in-depth study.

Modify QCM electrodes and nanoparticles with substances that can bind to heavy metal ions to further improve the detection sensitivity and overcome the interference of non-heavy metal ions.

A substance that can specifically bind to a certain type of heavy metal ion is found, and it is applied to this method to achieve more selective detection of heavy metal ions.

Further improve the stability and sensitivity of detection instruments based on electrochemical technology to improve detection sensitivity and reproducibility.

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