Application and Research of Analytical Chemistry Technology in Food Safety Testing

Hongling Kang, Yinan Liu, Shuang Hu, Xin Liu, Man Wang, Wan Sun, Lihua Chen and Rong Yan*
Shenyang Institute of Technology, Fushun 113122, China
*Corresponding author: yanrong1982218@situ.edu.cn

Abstract. Food safety problems occur frequently, and the food safety problems of major enterprises are continuously reported. Therefore, food safety quality and how to test food safety have become the focus of people's attention. The technical testing of food safety is mainly achieved through chemical means, but with the continuous development of science and technology, the disadvantages of chemical testing technology continue to appear, so how to improve the chemical testing technology has become a difficult problem to be overcome in the technical field. The thesis focuses on various chemical technologies in food safety testing, such as electrochemical immunosensors, liquid chromatography detection, pigment rapid testing instruments, nucleic acid aptamers, etc., and selects several items for detailed description.

Keywords: Food safety detection, electrochemical immunosensor, liquid chromatography detection, pigment rapid measurement instrument, chemical technology.

1. Introduction
Food is the basic demand of people's lives, and food safety is one of the topics that the society focuses on. Food safety problems are mainly caused by food-related ingredients, so scientific chemical detection technology has become an important means of food ingredient detection. Food safety is a long-term and difficult task that needs to be completed by all sectors of society. Nowadays, people have higher and higher requirements on food safety, and more and more research on food safety detection technology has provided diversity and comprehensiveness for food safety detection. Food safety is closely linked to human health, and it is the responsibility of the food safety management department to ensure social harmony and stability. After the incidents related to food safety have been exposed one after another, food safety issues have become the focus of attention in various fields in China. For example: toxic milk powder, toxic capsules, drain oil, and yogurt with non-compliant chemical ingredients. Even though the Food Safety Law of our country expressly stipulates the types and dosages of additives that can be used in food production, food safety issues are still prohibitive. The relevant departments of food safety management should summarize the causes of these accidents and take active measures to avoid the recurrence of food safety accidents. From the current perspective, food safety problems mainly come down to the following: pollution by toxins and heavy metals,
illegal use of hormones and antibiotics, excessive levels of pesticides, unreasonable food additives, sales of spoiled foods, non-standard food ingredients and excessive microorganisms [1].

2. Electrochemical immunosensor food safety analysis

2.1. Concept analysis

Electrochemical immunosensors are another research direction that has attracted much attention. This is mainly because electrochemical sensing technology has become very mature and popular. If the combined signal of antigen and antibody can be converted into an electrochemical signal, and then amplified and processed, it can realize the rapid and specific quantitative detection of antigen, hapten or pathogenic bacteria with the antigen by using the electrochemical signal system. The key issue in this regard is: how can the weak signal of the combination of antigen and antibody be converted into a sufficiently strong electrochemical signal, and then be amplified.

In terms of immunosensors, a major challenge is how to achieve commercial applications. Because its commercial application faces many key issues: 1) Must be able to achieve rapid, quantitative and large-scale sample determination. 2) High specificity, no obvious interference caused by cross reaction. 3) High-quality operating specifications. 4) The measurement fee is acceptable. 5) Repeatability and sensitivity are high enough. 6) The regeneration performance is good, and the half-life is long enough. The main ways to solve these problems are: 1) increase the measurement sensitivity and increase the amount of antibody adsorption to increase the number of samples for measurement; 2) increase the half-life and regeneration capacity of the nano-immune electrode. Electrochemical immunosensors have the advantages of high sensitivity, low cost, flexibility and portability, and have great application prospects in food safety detection. The following is a brief description of protein molecules, bacteria, toxins and pesticide residues. In this chapter, the visual analysis of aflatoxin B1 by nucleic acid aptamers is used as an entry point to analyse the application of electrochemical immunosensors in food safety [2].

2.2. Application of nucleic acid aptamer in aflatoxin B1

2.2.1. Principle analysis. SELEX technology is selected from random single-stranded oligonucleotide sequence libraries and has high affinity and specificity for nucleic acid aptamers to target substances. The basic principle is to synthesize a random single-stranded oligonucleotide library in vitro, mix it with the target substance, incubate, the target substance and nucleic acid combine to form a complex, and use a certain method to combine with the target substance or the weak binding force The nucleic acid is separated and removed to obtain a nucleic acid that binds stably to the target substance. The nucleic acid molecule is used as a template for PCR amplification and the next round of screening. After several rounds of separation screening and amplification, some DNA or RNA molecules that do not bind to the target substance or have weak binding ability are eliminated, and DNA or RNA with high affinity for the target substance is selected from the random library, and finally the high-affinity oligonucleotide chain to which the target molecule specifically binds, that is, the aptamer of the target molecule. Screening from random single-stranded oligonucleotide libraries to obtain nucleic acid aptamers with strong specificity mainly depends on the in vitro screening technology of SELEX (Figure 1).
2.2.2. Experimental design. The aptamer oligonucleotide sequence of aflatoxin B1 is 5'-GCATCACAGCAGGTAACCAGGAACTGA-GGAGTGGGAGGTAAATCGTGTGAAGTGCTGTCCC-3', diluted with 10mmol/L PBS (pH=7.4) solution containing 1mmol/LMgCl2 (pH=8.5), Store at -20℃. Aflatoxin B1 standard, chloroauric acid (HAuCl4), trisodium citrate were purchased from American Sigma Company, NaCl, Na2HPO4, KH2PO4, MgCl2 and other reagents were purchased from Shanghai Chemical Reagent Company, and the reagents used in the experiment were all analytically pure. Take 50 μL of AFB1 aptamer DNA at a concentration of 10 μmol/L, add it to a 96-well plate, add 50 μL of different concentrations (0, 0.025, 0.1, 0.4, 2, 4, 10, 20 ng/mL) of the target, mix and incubate After 5 minutes, add 50 μL of gold nanoparticles, equilibrate for 5 minutes, add 10 μL of 2 mol/L NaCl, and after equilibrating for 5 minutes, use 400 nm to 750 nm as a reference for comparison with water, and take pictures.

2.2.3. Experimental results. The principle of visual detection method using AFB1 aptamer and nano-gold is based on the color change caused by the aggregation of nano-gold solution under the action of high concentration NaCl. Nano-gold is generally prepared by reducing chloroauric acid with trisodium citrate. The resulting solution is a colloidal solution. The surface of the nano-gold is covered with a layer of citric acid. The particles maintain the stability of the colloidal gold solution through electrostatic repulsion. Adding a high concentration of salt to the solution can destroy the stability of the colloidal solution, the nano-gold coagulates, and the color of the solution changes from red to blue. In the free state, single-stranded DNA is directly adsorbed to the gold surface through the exposed positively charged bases and the negative charge on the surface of the gold nanoparticles, and the gold nanoparticles adsorbed with single-stranded aptamer DNA are under high salt concentration. Can still be stable, the solution is red. When the target molecule AFB1 is present in the solution, the aptamer single-stranded DNA forms a specific three-dimensional structure, which specifically binds to AFB1 with high affinity. The nanogold that does not adsorb DNA on the surface condenses after adding a high concentration of salt, and the solution turns blue color. Using a spectrophotometer to measure the absorbance of the solution, a linear relationship can be established by the concentration of the target and the absorbance. In order to study the specificity of the AFB1 aptamer, in this study, ochratoxin OTA was selected as a potential interferer, and the aptamer was tested against AFB1 (0.25ng/mL) and OTA (0.25ng/mL) under the same conditions. Choose specificity and sensitivity. As shown in Figure 2, compared with the blank control, that is, compared with the solution without aptamer DNA without the target, the UV-visible absorption spectrum of the solution with AFB1 target added has a significant drop at 520nm, and The spectral line of the solution with OTA as the target only changed a little. The data shows that the change rate of the absorbance of the target added with AFB1 is significantly higher.
than that of OTA. These results indicate that the aptamer sequence used in this method has good selectivity, and the visualization method established for detecting AFB1 based on this method has good specificity.

![Figure 2](image-url)

**Figure 2.** The specificity of the aptamer-gold nano-detection method (OTA is the interferer)

### 2.2.4. Experimental conclusion.

The concentration of the AFB1 aptamer, the concentration of NaCl salt solution, and the pH value are the key factors in the reaction system of this detection method. By comparing different concentrations of DNA, NaCl solution, and pH value, the optimal reaction conditions are determined to obtain the ideal sensitivity. Precision and test results. When quantifying based on the colorimetric method, due to the slight difference in the absorbance of 520 nanometres of different batches of gold nanoparticles, when the conditions such as aptamer and salt ion concentration in the solution are not fixed, the absorbance will be affected, although its change trend and linear repeatability is very good. Therefore, if this method is used for quantitative detection, it is necessary to ensure the consistency of the above elements.

### 3. Liquid chromatography method to detect the content of methylene blue in water safety

#### 3.1. Overview

In this study, the ion-pairing reagent was used to extract the methylene blue (MB), demethylated (AZB), demethylated (AZA) and DE trimethylated (AZC) metabolites in aquatic products, MCAXSPE cartridge purification, 630 Detect AZA at nm, AZC at 610 nm; MB and AZB at 660 nm. The method is sensitive, stable and reliable, and is suitable for the detection of methylene blue and its metabolites in aquatic products [3].

#### 3.2. Experimental design

Weigh 5g sample, add 5mL of p-toluene sulfonic acid-ammonium acetate buffer (pH=3.0), homogenize for 3min, extract ultrasonically with 2×15mL acetonitrile at 70°C for 20min, centrifuge, combine the acetonitrile layers, use 2×10mL acetonitrile Degrease the saturated n-hexane, centrifuge, discard the n-hexane phase, back-extract with 2×25mL dichloromethane, collect the acetonitrile-dichloromethane layer, concentrate at 40°C under reduced pressure and nearly dry, dissolve the residue with 5mL acetonitrile. MCAXSPE column, rinsed with 5mL of acetonitrile, and eluted with 3mL of 20mol/L ammonium acetate (containing 10% formic acid)-methanol solution (5:95, V/V), collect the eluent in a graduated pipette, and blow nitrogen to near dryness Vortex the mobile phase to dissolve the residue and dilute to 0.5mL, to be measured. AgilentEclipseXDB-C18 column
isocratic elution, mobile phase is 100mmol/L ammonium acetate solution (which contains 0.5% heptafluorobutyric acid, pH=4.5)-acetonitrile (70:30, V/V), the flow rate is 1.0mL/min; the detector is a diode array detector, the detection wavelength for methylene blue (MB) and azure B (AZB) is 660nm; the detection wavelength for azure A (AZA) is 630nm; the detection wavelength of azure C (AZC) is 610nm, the reference wavelength is 700nm; the column temperature is 35°C; the injection volume is 50µL.

3.3. Results
Since methylene blue and metabolites are dyes, they are tightly bound to tissues and cells, so it is necessary to select appropriate solvents for extraction. In the experiment, acetonitrile, acetonitrile-acetone, acetonitrile-ammonium acetate buffer solution and acetonitrile-p-toluene sulfonic acid-ammonium acetate buffer solution were used for extraction. The effects of different extraction solvents on recovery rate are shown in Table 1. The results show that it is difficult to obtain a good extraction effect with a simple organic solvent, and the recovery rate is only about 35%-57%.

Table 1. Effects of different extraction solvents on recovery

| Extraction solvent                                    | Recovery rate |
|-------------------------------------------------------|---------------|
|                                                        | Methylene blue| Azure A | Azure B | Azure C |
| Acetonitrile                                           | 53.6          | 46.2    | 57.3    | 42.3    |
| Acetonitrile-acetone                                   | 45.3          | 37.6    | 49.2    | 35.4    |
| Acetonitrile-ammonium acetate buffer solution          | 68.7          | 55.6    | 72.3    | 48.7    |
| Acetonitrile-p-toluene sulfonic acid-ammonium acetate  | 90.3          | 88.7    | 89.5    | 79.8    |

After adding buffer, the extraction efficiency has been improved. Since the four analytes are all cationic compounds, p-toluene sulfonic acid as an ion pair reagent can form ion pairs with analyte molecules, which significantly improves the extraction efficiency of acetonitrile. This study also investigated the effect of the pH of the extract on the extraction efficiency. The extraction solution was adjusted to different pH values with HCl or NaOH, and the recovery rate experiment was conducted. The results are shown in Figure 3. It is ideal when the pH is 3.0.

![Figure 3](image-url)

Figure 3. The effect of the pH value of the extract on the recovery rate
3.4. Research results
The four compounds in the water quality have a good linear relationship in the range of 0.005-0.50 mg/kg, and the correlation coefficient is 0.9946-0.9978. In the concentration range of 0.005-0.5mg/kg, the average recovery rate of standard addition is 75.9%-93.2%; the relative standard deviation is 3.3%-11.9%; the detection limits of AZA, AZB, AZC, and MB are 1.27, 0.98, 1.48 and 1.33 μg/kg. The method is stable and reliable, and can meet the detection needs of methylene blue and its metabolites in aquatic products.

4. Application of Pigment Detector in Food Safety Testing

4.1. Experimental design
Pigment standard solution: lemon yellow, sunset yellow, amaranth, carmine, brilliant blue standard solution, diluted with deionized water before use; polyamide (0.154-0.180mm, 80-100 mesh); methanol: Filtered through a 45mm filter membrane; 0.02mol/L ammonium acetate solution; 2% ammonia water; 20g/L citric acid solution; methanol-formic acid (6:4, V/V) solution; anhydrous ethanol-ammonia water-water (7: 2:1, V/V) solution; pH 6.0 buffer solution: deionized water plus 20% citric acid. For beverage samples that do not contain natural pigments, if the beverages such as soda and glucose water can be degassed and filtered directly, diluted and tested; for jelly samples, weigh 5g of jelly, crush it first, add water and stir at 70℃ constant temperature After all the pigments are dissolved in water, it will be treated according to the polyamide adsorption method. For the hard candy sample, weigh 5g of the sample, after crushing, dissolve it warmly, and treat it according to the polyamide adsorption method. In the detection of pigments in toned wine samples, an appropriate amount of sample is weighed, several pieces of broken porcelain pieces are added, ethanol is removed by heating, and treatment is conducted according to the polyamide adsorption method. Take 6mL of the test solution, transfer it to a 2cm cuvette, place it in a synthetic pigment rapid tester, let it sit for a few seconds. After the instrument is stable, start the detection button, the computer automatically processes the spectrum data, and displays the content of each synthetic food pigment [4].

4.2. Detection system method
The detection system includes components such as tungsten lamps, colorimetric tanks, photocells and data acquisition cards powered by a regulated power supply module. The software system mainly includes data processing and storage. In the rapid detection of pigments, the visible light emitted by the tungsten lamp passes through the colorimetric tank, and the corresponding light signal intensity change after the light is absorbed by the solution is collected by the CCD acquisition module, and the optical signal is converted into A/D digital-analogy conversion The electrical signal is controlled by the single-chip computer, and finally transmits the data to the computer through the USB interface [5].

4.3. Experimental results
The measurement of the ultraviolet-visible absorption spectrum of five kinds of artificial pigments found that these synthetic pigments have obvious absorption peaks in the visible region. The maximum absorption wavelengths of lemon yellow, sunset yellow, carmine, amaranth, and brilliant blue in the visible region are 426, 482, 510, 521, and 629 nm, respectively (Figure 3). Therefore, 400-700nm is selected as the measuring wavelength, and a synthetic pigment fast tester combined with partial least squares variable screening method is used to establish a synthetic pigment prediction model. Partial least squares variable screening method is suitable for dealing with the modelling problem of massive variables. It mainly selects the original independent variables based on some information such as regression coefficients in partial least squares modelling, without losing the forecasting ability of the model. It is a very effective and practical variable screening method to remove some original independent variables that are redundant or have little influence, so that the resulting model is greatly simplified. Remove all sample sets of a certain sample point i as a sample and use h components to fit a regression equation; then substitute the excluded sample point i into the
previously fitted regression equation to obtain the fitted value of $y_i$ at sample point $i, \hat{y}_{h(-i)}$. Repeat the above calculation for each sample point, and define the sum of squared prediction errors of $y_i$ as $press_h$, with:

$$press_h = \sum_{i=1}^{n} [y_i - \hat{y}_{h(-i)}]^2$$  \hspace{1cm} (1)

In addition, all sample points are used to fit the regression equation containing $h$ components. At this time, the predicted value of the $i$-th sample point is $\hat{y}_{h}$, then the sum of squared errors of $y_i$ can be defined as $ss_h$, which is:

$$ss_h = \sum_{i=1}^{n} [y_i - \hat{y}_{h}]^2$$  \hspace{1cm} (2)

Generally speaking, there is always $press_h > ss_h$ and $ss_h < ss_{h-1}$. The comparison between $ss_{h-1}$ and $press_h, ss_{h-1}$ is the fitting error of the equation with E(h-1) components fitted with all sample points. $press_h$ adds a component $t_h$, but however, it contains the perturbation error of the sample point. If $press_h$ is less than $ss_{h-1}$ to a certain extent, it is considered that adding a component $t_h$ will significantly improve the accuracy of prediction. Therefore, it is hoped that the smaller the ratio of $press_h / ss_{h-1}$, the better.

![Figure 4. UV-Vis absorption spectrum of synthetic pigment](image)

**Figure 4.** UV-Vis absorption spectrum of synthetic pigment

4.4. Research results

The synthetic pigment rapid tester has stable performance, simple and fast determination, and reliable. The actual sample detection RSD is less than 5%, which can meet the requirements of rapid on-site detection of synthetic pigments [6].

5. Conclusion

With the progress and development of the times, social economy and science and technology are also innovating and developing. Environmental issues and food safety related issues are gradually paid attention and attention by people from all walks of life. Therefore, the active application of rapid detection technology in the field of environmental protection and food safety can effectively improve
the detection effectiveness of the environment and food, optimize the natural ecological environment, and provide a solid foundation for food safety assurance.

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