The Rapid Detection of Microbes Based on Piezoelectric Sensor

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Abstract: piezoelectric sensor has certain advantages in many aspects, which can be embodied in its sensitivity and operation process. These advantages determine that it can be applied in real-time detection and bit detection. The main direction of the application of piezoelectric sensor by chemistry, environmental monitoring, etc, this paper will be on its application in rapid detection of microbial inspection method of the corresponding research, instruments as a basic overview of research progress on the detailed biological detection method, give full play to its corresponding characteristics of characteristics, and microbial complement each other, the biological characteristics to achieve the purpose of improve the accuracy of the information.

1. Research Progress of piezoelectric sensors

At present, there are many kinds of piezoelectric sensors, the most common of which is piezoelectric quartz crystal sensors. Piezoelectric immunosensors are one of them. As shown in Fig. 1, the working principle of this sensor is to make use of the high sensitivity of quartz crystal to surface load quality and the recognition between different antigens, while in practical applications, the fixed antibody type is mainly used to detect the antigen, and the main antibody type is monoclonal antibody. Because monoclonal antibodies have the characteristics of targeting a certain determinant of antigen, they are also very effective in detecting the reduction of reaction, and in the current research, it is also aimed at this. Features to complete its practical application.

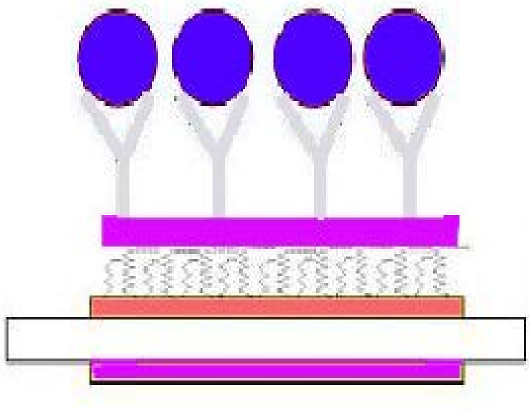

Fig. 1 schematic diagram of piezoelectric immunosensors

1.1 Response principle of piezoelectric sensor

Piezoelectric sensors have some shortcomings at present. In order to supplement the above shortcomings, relevant modifications are made to the piezoelectric sensors, which are only used as serial piezoelectric sensors. In terms of principle, the serial piezoelectric sensor is designed to connect the quartz crystal involved in the gas phase oscillation with the conducting electrode in series. In order to demonstrate its principle in detail, a picture is attached below, as shown in figure 2. It is this form that allows the crystal to be tightly sealed, which also helps solve the problem of corrosion. Largely for piezoelectric body's life is a kind of ascension, also by the content of figure 2 can find tandem piezoelectric sensor has a certain relationship between the oscillation frequency

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and conductivity, it is also in order to confirm this view relevant researchers cited the formula, and through the formula derivation to obtain the detection limit.

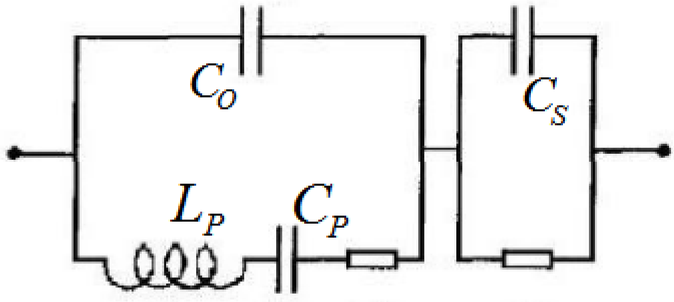

Fig.2 Equivalent circuit diagram of piezoelectric sensor.

Among:

$$Z = R + jX = \frac{G_S - J\omega C_S}{G_S^2 + \omega^2 C_S^2} + \frac{j(\omega L_q - \omega^{-1} C_q^{-1})}{1 + {C_0}/{C_q} - \omega^2 L_q C_0} \quad (1)$$

$$Y = \tan\theta = {X}/{R} \quad (2)$$

From the phase condition:

$$\frac{G_S Y - \omega C_S}{G_S^2 + \omega^2 C_S^2} + \frac{\omega L_q - \omega^{-1} C_q^{-1}}{1 + {C_0}/{C_q} - \omega^2 L_q C_0} = 0 \quad (3)$$

The oscillation frequency F can be obtained from the above formula as follows:

$$F = F_0\left[1 + \frac{\pi F_0 C_q (2\pi F_0 C_S - Y G_S)}{G_S^2 - 2\pi F_0 C_0 Y G_S + 4\pi^2 F_0^2 C_S (C_0 + C_S)}\right] - \pi F_0 C_q R_q Y (4)$$

Of which F_0 Marked as the natural frequency of oscillations, R_q Recorded as dynamic resistance.

1.2 Piezoelectric sensor construction

As early as the 1980s of last century, the single-surface contact experiment between overvoltage electric quartz crystal and contact liquid was carried out. Meanwhile, this experiment was also successful, which laid a foundation for the subsequent success of two-face contact liquid experiment and formally established the research beginning of piezoelectric sensor application. In many subsequent experiments, it can be found that there is a certain correlation between the sensitivity of piezoelectric quartz crystal and the gas phase sensitivity, and the related influencing factors also include conductivity, viscosity and so on. Such as response pattern research gradually thorough also promoted the development of piezoelectric sensor, but because of its large number of patterns in providing convenience but also make them influenced by a certain selectivity, and it also can produce certain effect for the future study, at the same time, the stability of liquid phase piezoelectric quartz crystal are under the influence of the solution and its stability is better than the gas phase piezoelectric quartz crystal. See figure 3 for details, structure diagram of piezoelectric sensor.

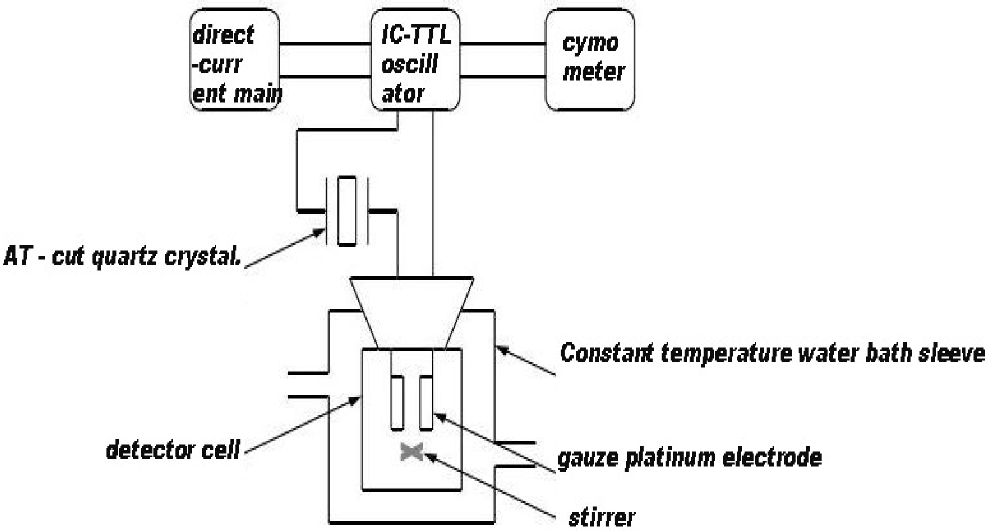

Fig. 3 Construction diagram of piezoelectric sensor

Among them, array microelectrode is widely used, which is characterized by miniaturization. The one-dimensional size of electrode is compressed to the micron level or even nanometer level. As the electrode size drops from millimeter to micron and nanometer, its electric field distribution will be different from that of the flat plate electrode. See figure 4.

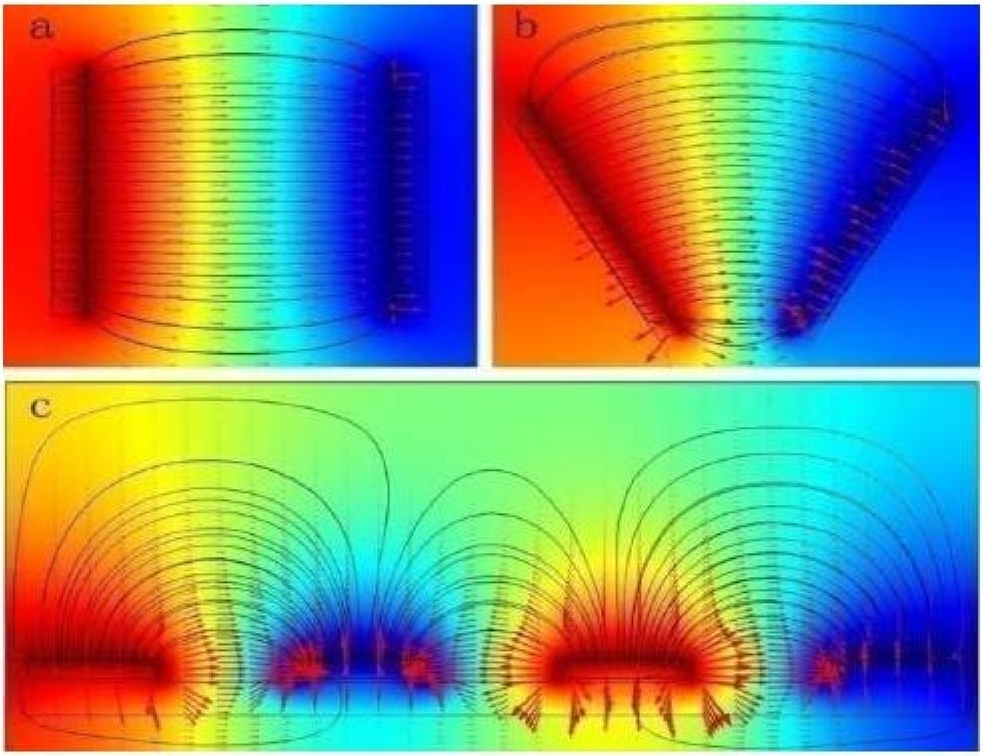

Fig. 4 Array microelectrode series piezoelectric sensor

2. Microbial identification method

2.1 Polymerase coupling reaction (PCR) technique

The specificity is not high in the clinical aspect. The results of electrophoresis were inaccurate, there were inhibition factors in the specimen, the pretreatment of the specimen was related to the methods of DNA extraction, and it had the characteristics of high sensitivity, strong specificity and rapidity.The detection of false positives and false negatives as the important influence factors in testing, extremely easy to produce the problem such as reagent quality, improper operation method, PCR according to afore-mentioned problems, can be effectively solved, and derived the commonly used the related technology, the cases of "reverse transcription PCR (rt-pcr), multiple PCR and nested PCR, PCR single-strand conformation polymorphism (PCR - SSCP), RFLP, RApd technique, fluorescence quantitative PCR". All the above technologies can be used for PCR amplification by using nucleic acid samples, which plays a very common role in preventing clinical infection and in judging the identification of pathogenic bacteria and the differentiation of subtypes.

2.2 Immunization of PCR

Immunopcr is a highly sensitive technique for detecting trace antigens. It can be refined and combined according to the sensitivity and high specificity of polymerase chain reaction in antigen-antibody reaction. As shown in figure 5, the reaction principle is to mark the DNA molecular marker antibody as the detection object, fully react its DNA molecular marker antibody with the antigen to be tested, use PCR amplification to bond the antibody complex after the reaction of its antigen body to the DNA molecule, and determine its electrophoretic characterization. The antigen was determined according to whether PCR products were output after the reaction. Immunopcr can replace ELISA and is more sensitive. The semi - quantitative test of antigen can also be carried out when the amount of antigen can not reach saturation.

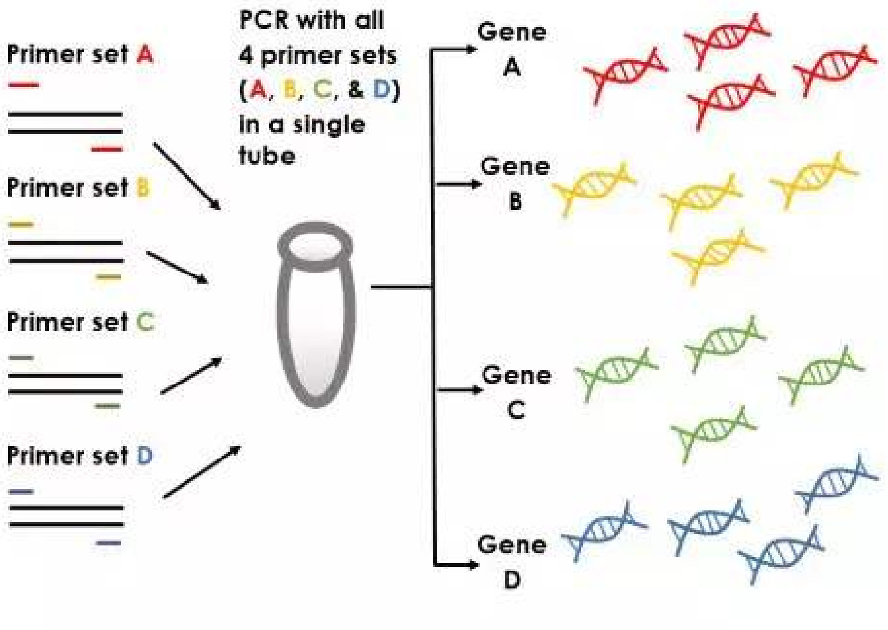

Fig. 5 schematic diagram of immune PCR response principle

3. Research on rapid detection method of microbial test based on piezoelectric sensing

With the continuous development of life science, people pay more and more attention to the establishment of fund base. Different from the general chemical system, it has its own laws and uncertainties. The combination of piezoelectric sensor and its subject has the characteristics of its subject, emphasizing qualitative and quantitative. In the rapid examination of microorganisms. Carry out unified research on proteins, enzymes, blood cells, microorganisms, nucleic acids and other aspects, starting with PCR technology. As shown in FIG. 6, the piezoelectric microbial sensor can determine its bacteria according to the quality benefit of its technology. In terms of its quality benefit, according to the corresponding antibodies of the bacteria to be tested on the crystal, antibodies and microorganisms can specifically bind with each other by increasing the mass load of the crystal, and the frequency changes. Example: "anti-igg modified electrode to detect staphylococcus, anti-escherichia coli antibody electrode to detect escherichia coli", etc. In terms of salmonella, antibody binding method is adopted for detection. Generally, optimization experiments are carried out by improving antibody purity, narrowing the response range of bacterial concentration, improving sensitivity and other measures. In the study, it was found that there was a relationship between the sensor and the detected substance, and the non-mass response of the piezoelectric crystal was used to determine the composition of its microorganisms, so as to control the growth rate of bacteria. According to the chemical properties of the culture medium, escherichia coli was measured by tandem and piezoelectric sensors in a range of 10~10'efu/ml. The growth rate was measured in the medium, and the concentration of the culture medium was investigated to determine the growth of escherichia coli.

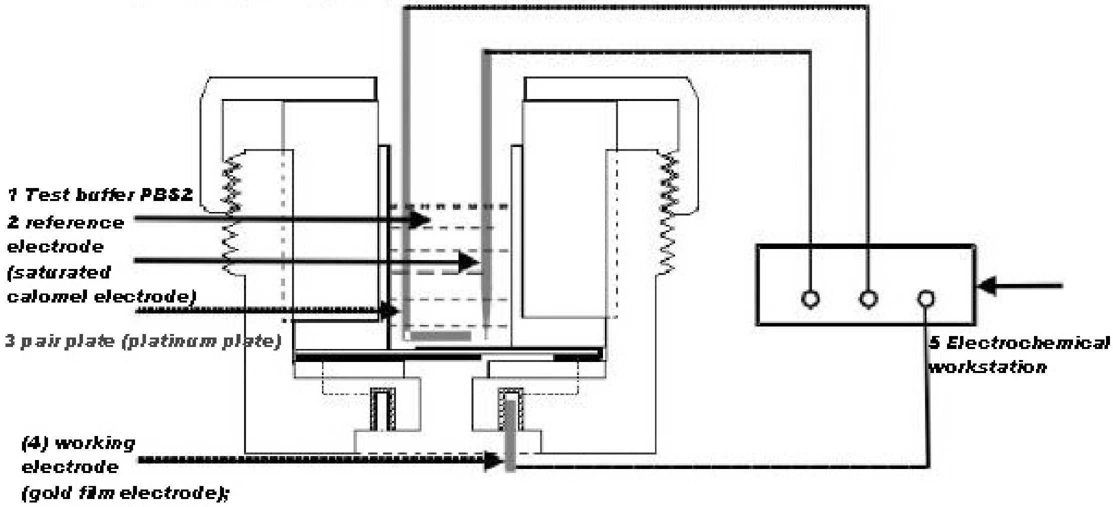

Fig. 6 schematic diagram of piezoelectric microbial sensor construction

4. Conclusion

Through the discussion in this paper, it can be found that piezoelectric sensor, as a new type of sensor, can help combine the sensitivity of piezoelectric sensor with microbial metabolism, and it is in this way that its performance can be highlighted. However, relevant research is still in its infancy, so there are still many problems to be solved in this process. The future research should be carried out separately and separately. Firstly, piezoelectric sensors should be constructed to complete microbial detection in this way, and various variables in this process should be considered to find a more perfect detection method. Secondly, the device in combination with the microbial detection process is redeployed, and the influence factors of variables are calculated by comparative test, and the influence of their metabolism is further studied.

References

[1] Schwab Laura,Rago Laura,Koch Christin,Harnisch Falk. Identification of Clostridium cochlearium as an electroactive microorganism from the mouse gut microbiome.[J]. Bioelectrochemistry (Amsterdam, Netherlands), 2019,130.

[2] Weiping Li,Shaokang Zhang,Lieyu Zhang,Xiaoguang Li,Fan Wang,Guowen Li,Jiaxi Li,Wei Li. In-situ remediation of sediment by calcium nitrate combined with composite microorganisms under low-DO regulation[J]. Science of the Total Environment, 2019,697.

[3] Cheng Zhang,Tongtong Zhou,Lusheng Zhu,Albert Juhasz,Zhongkun Du,Bing Li,Jun Wang, Jinhua Wang,Yan'an Sun. Response of soil microbes after direct contact with pyraclostrobin in fluvo-aquic soil[J]. Environmental Pollution, 2019,255(Pt 1).

[4] Laura Schwab,Laura Rago,Christin Koch,Falk Harnisch. Identification of Clostridium

cochlearium as an electroactive microorganism from the mouse gut microbiome[J]. Bioelectrochemistry, 2019,130.

[5] Maocai Shen,Guangming Zeng,Yaxin Zhang,Xiaofeng Wen,Biao Song,Wangwang Tang. Can biotechnology strategies effectively manage environmental (micro)plastics?[J]. Science of the Total Environment, 2019,697.

[6] R. Becerril,S. Manso,C. Nerín. Metabolites identified as interaction products between EOs from food packaging and selected microorganisms[J]. LWT,2019,116.

[7] Mengjiao Wang,Baiwan Deng,Xun Fu,Haiyan Sun,Zhimin Xu. Characterizations of microbial diversity and machine oil degrading microbes in machine oil contaminated soil[J]. Environmental Pollution,2019,255(Pt 1).

[8] Olugbenga Oludayo Oluwasina,Ifunanya Vivian Ezenwosu,Clement Olusola Ogidi,Victor Olusegun Oyetayo. Antimicrobial potential of toothpaste formulated from extracts of Syzygium aromaticum, Dennettia tripetala and Jatropha curcas latex against some oral pathogenic microorganisms [J]. AMB Express,2019,9(1).

[9] Kunal Jani,Jayashree Bandal,Vinay Rale,Yogesh Shouche,Avinash Sharma. Antimicrobial resistance pattern of microorganisms isolated and identified from Godavari River across the mass gathering event[J]. Journal of Biosciences,2019,44(5).

[10] Qiongqiong. YaoResearch and application of a new generation of multi-channel series piezoelectric blood culture system [D]. Hunan University, 2017.

[11] Yuting. ZhouPreparation and activity determination of Aspergillus flavus spores as glucose Oxidase biocatalyst [D]. Central South University of Forestry Science and Technology, 2016.

[12] Jing. LiuConstruction of a novel aptamer sensor and its application in rapid detection of Mycobacterium tuberculosis [D]. Hunan University, 2015.

[13] Feifei. Tong Construction and Application of Multi - Channel Series Piezoelectric Cell Sensor [D]. Hunan University, 2015.