Simulation of Capture Capability based on Rectangular Ion Trap

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Abstract: In the ion optical simulation software, the capture capability of RIT designed was studied by simulation, thus affecting researches on initial position and radio-frequency voltage of ion trap. Thereinto, both frequency and voltage are the main influence factors of capture capability based on RIT. Simulation shows that the smaller the distance between ion and the center of ion trap, the more the possibility of capture. Therefore, suitable radio-frequency voltage and distance should be designed to ensure high-probability capture. In the work, the simulation demand in practice is analyzed in term of research on capture capacity of RIT.

1 INTRODUCTION

With development of society, and progress of science and technology, quality and safety detections of food and supplies draw more and more attention. The technical instruments for detection are influenced and developed towards the direction of intelligence and miniaturization, thus affecting design of mass spectrometer to some extent. As the core component of mass spectrometer, the mass analyzer plays an important role in the solution of mass spectrometer technique. In so many technical instruments, RIT is suitable for design standard of modern mass spectrometer, with prominent advantages. Consequently, simulation of capture capability of RIT is analyzed based on ion simulation software to further analyze technical advantages in RIT design and application.

2 CONCEPT OF RIT

In the work, the concept of RIT is analyzed to present its technical advantages in the process of application and technical standard in mass spectrometer.

2.1 Analysis on Concept of RIT

RIT is a kind of instrument consisting of two circular electrodes and one end electrode. In general, circular electrode is loaded with radio-frequency voltage or DC power, meanwhile, with end electrode earthed. With this structure, ion instability region will be formed when the voltage reaches a certain value. Then the corresponding mass spectrogram will emerge when mass-change ratio constantly increases. This principle of ion mass spectrometry plays an important role in accurately identifying material structure.

2.2 Development Significance of RIT

In real life, detection is very important. Mass spectrometer, as one of common and effective analytic instruments in professional detection filed, is mainly used for material identification and qualitative analysis. In mass spectrometers, especially in high-end instruments, RIT technology is more frequently used to capture mass spectrometry, thus achieving testing effect. With development of science and technology, more and more ion identification techniques, used in practical instruments, have become effective testing methods. Mass spectrometer of RIT is a simplified mass analyzer on basis of traditional ion trap. Consequently, in actual detection, RIP will be better used and developed with the simplification of the mass spectrometer.

2.3 Research Background and Meaning of Mass Spectrometer based on RIP

With development of society and economy, living standard and material requirements of people are

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improved, bringing about some social problems such as food safety problem. In addition, the problems of military technology and public safety detections draw unprecedented attention. Therefore, the mass spectrometer is selected to solve quality and safety problems above. At present, research on the mass spectrometer is done as follows: on the one hand, the mass spectrometer, with high quality, sensitivity and accuracy, is developed for high-accuracy experiment of academic research; on the other hand, the rapider and smaller mass spectrometer is developed for application in daily life. The high-accuracy mass spectrometer is huge, complicated and inconvenient for application in actual life. So, the spectrometer, getting smaller and rapider, is developed based on RIP --- the core technology of mass analyzer in the spectrometer.

Therefore, quality detection is needed in all fields of life, thus causing the occurrence of mass spectrometer based on RIP. By means of development of small-sized mass spectrometer with high monitoring efficiency, rapid and effective detection can be carried out, thus achieving professional and high-frequency results in field detection. Consequently, mass spectrometer based on RIP has a great significance in controlling quality and safety, as well as effectively solving material and life problems of modern society.

2.4 Application Field of Mass Spectrometer based on RIP

The above advantage analysis derives that mass spectrometer based on RIP can be widely used in many fields, presented as follows.

2.4.1 Real-time Detection of Dangerous Goods

With development of society, dangerous goods cause a lot of trouble to people. Therefore, in detection field of dangerous goods, mass spectrometer is widely used to rapidly and accurately detect dangerous goods, thus decreasing the damage caused by dangerous goods to some extent.

2.4.2 Rapid Detection in Non-working Region

Large detection instrument with high accuracy cannot be applied in many cases such as hostile field detection environments. So, detection instrument based on RIP is developed for rapid and effective field detection.

2.4.3 Detection in Closed Environments

Mass spectrometer can be used for index detection to get accurate results in closed environments, for example, a spacecraft. With development of aerospace industry, more and more mass spectrometers are applied for aeronautic detection and widely recognized.

2.4.4 Quality Detection in Industrial Production

Mass spectrometer, widely used in test department, is often applied for spectrum detection of products in industrial production. Quality of industrial products can be effectively identified using mass spectrometer, thus improving the whole quality of products and ensuring quality in application.

3 OPERATION PRINCIPLE OF MASS SPECTROMETER

With development of society, and progress of science and technology, quality and safety detections of food and supplies have drawn more and more attention. The technical instruments for detection are influenced and developed towards the direction of intelligence and miniaturization, thus affecting design of mass spectrometer to some extent. Mass spectrometer is an instrument for detection in daily life, of which mass analyzer is the core. Besides, RIP is the core of mass analyzer. In general, instruments such as mass spectrometer are used for detection of food, industrial products and military field. So, mass analyzer, as the core instrument of mass spectrometer, is analyzed. Furthermore, RIP, as the core of mass analyzer, is analyzed.

RIP of small and rapid mass spectrometer is analyzed. In daily application, small mass spectrometer is widely used with advantages such as convenience and rapidness. Actually, principle of mass spectrometer based on RIP is spectrum forming and analysis. Each substance to be detected has fixed spectrum. If the spectrum is found with problem in the process of detection, certain abnormal spectrum will be formed. Then the conclusion will be achieved according to spectrum analysis.

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4 SIMULATION OF CAPTURE CAPACITY BASED ON RIT

Application principle of mass spectrometer is analyzed according to concept and practical application of mass spectrometer based on RIT. Mass spectrometer, the most widely used in practical detection, should be rationally applied to achieve efficient, accurate and rapid detection. Capture capacity of RIT is researched to get actual testing results, thus ensuring accuracy and efficiency of mass spectrometer. Consequently, the work focuses on simulation of capture capacity based on RIT.

4.1 Establishment and Research of Geometry Model based on RIT

Combined with linear and cylindrical ion traps, geometry model of RIT is established to achieve better programming and analysis of capture capacity based on RIT by means of a fixed model. Linear ion trap has advantages such as large amount of information and high efficiency of capture, and the cylindrical ion trap is easy to process and install. Therefore, geometry model of RIT is excellent by uniting advantages of the above two ion traps. Taking a $20\times20\times40$ cuboid region as the internal electric field, geometry model of RIT is designed according to the ratio of one-one in the work.

4.2 Design and Analysis of Simulation Program of RIT

Research on simulation of capture capacity of RIT requires programming as well as geometry modeling. Geometry model is established for better programming. For geometry model of RIT, different programs can be compiled according to different simulations. By changing electric signal and simulation, electrode of the model can achieve independent control. Meanwhile, both frequency and phase of additional voltage are set as the common values to get a real simulation effect. In conclusion, all the simulation parameters can be compiled in the process of programming, thus achieving corresponding changes via actual situation.

4.2.1 Forming modes of initial position of ion in programming

In programming, the initial position of ion is formed by two different modes. Mode 1 is presented as follows. There are three coordinate axes, where the vertical is z-axis. Then a random point on z-axis can be set as the origin. Taking the origin as the center and a fixed value as the radius, a circle is drawn on the xy-plane, thus forming a circular region. A random point in the region can be selected as the initial position of ion. Mode 2 is a simplified way of Mode 1. In the circle of Mode 1, there are 4100 random points, where a certain point is selected as the initial position of ion. In fact, selecting the initial position is important for determination of other dynamic addresses to some extent.

4.2.2 Mode Design of Dynamic Capture Capacity in Programming

Dynamic capture capacity of RIT is designed in programming. Thereinto, dynamic mode of capture is discussed based on initial mode. In practice, initial position of ion has been designed. Ion will enter RIT and the voltage will increase when voltage is imported through voltage terminal. Via this process, ion in RIT, as well as the whole voltage, changes to derive captured data. This is dynamic capture process of RIT. Besides, mode of capture capacity is determined according to the results.

4.3 Impact Factors of RIT Capture Efficiency

In terms of the above design philosophy, only one port is conducted with voltage input in the initial stage. After ion enters RIT, the voltage of other ports will increase. This is the main impact factor of capture efficiency and the reason of ion capture delay.

5 CONCLUSIONS

The work puts forward reason and necessity of mass spectrometer application by means of analysis of mass spectrometer and its core technology RIT. The principle and concept of RIT is analyzed in process of capture simulation. Using the geometric model of RIT, the later principle design is conducted based on advantages of linear and cylindrical ion traps. Principles of programming and capture capacity are acquainted, and capture delay problems due to initial voltage are analyzed via simulation. In conclusion, capture principle of RIT is analyzed to develop principle, application of mass spectrometer.

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