MULTIPOLE INLET SYSTEM FOR ION TRAPS

FIELD OF THE INVENTION

This invention relates to the combination of a multipole (parallel rod) ion inlet and processing system with an ion trap mass spectrometer.

BACKGROUND OF THE INVENTION

Ion trap mass spectrometers (hereafter called ion traps) are well known devices for receiving and analyzing ions. Typical ion traps are shown in U.S. Pat. Nos. 4,736,101 issued Apr. 5, 1988 and 4,540,884 issued Sep. 10, 1985, both to Finnigan Corporation.

Ion traps typically employ a ring electrode and end caps which, when suitable RF and DC voltages are applied to them, provide a quadrupole field to trap ions within a storage region. However ion traps are usually relatively small in physical size and have the capacity to store only a limited number of ions. When the number of ions injected into an ion trap becomes too large, space charge effects occur which have a number of undesirable consequences. These consequences can include spontaneous emptying of the trap, shift in the mass calibration, distortion of the analysis results obtained from the ion trap, and the like.

In addition, when an ion trap is performing an analysis, it cannot accept additional ions. If a prolific ion source is used, the time taken to fill the ion trap can be much less than the time required for the ion trap to perform analysis. During the analysis time, the ions produced by the ion source may be wasted, resulting in a very low duty cycle for the ion trap and causing low sensitivity for the system.

BRIEF SUMMARY OF INVENTION

Accordingly, it is an object of the invention in one of its aspects to provide a method of analyzing ions in an ion trap comprising: producing a stream of said ions, directing said stream of ions into a two dimensional multipole RF field formed by an RF voltage applied to a set of parallel rods, storing some of said ions in said field within said rods and rejecting others of said ions from said rods, releasing the ions stored in said field within said rods into said ion trap, analyzing said ions in said trap, and while said ions are being analyzed in said trap, refilling said field within said rods with some ions from said ion stream while rejecting from said field within said rods other ions from said ion stream.

In another aspect the invention provides an ion inlet and processing system comprising: means for generating a stream of ions, a multipole set of parallel rods, means for applying an RF voltage to said rods for producing a two dimensional multipole RF field therein, means for directing said stream of ions into said set of rods, control means for controlling said rods to store some ions from said stream in said rods and to reject other ions from said rods, an ion trap, said control means including means for releasing ions stored from said rods into said ion trap, said control means including means for admitting new ions from said stream into said rods while said ion trap is performing an analysis, for said rods to store some of said new ions and to reject others while said ion trap is performing said analysis.

Further objects and advantages of the invention will appear from the following description, taken together with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

In the drawings:

FIG. **1** is a diagrammatic view of an inlet system and ion trap according to the invention;

FIG. **2** is a conventional stability diagram for a quadrupole mass spectrometer;

FIG. **3** shows the connection of an RF generator to quadrupole rods;

FIG. **4** shows the connection of an RF generator and an auxiliary RF generator to quadrupole rods; and

FIG. **5** shows details of an auxiliary RF generator.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

FIG. **1** shows a mass analyzer system **10** having a known ion source **12** such as the ion spray device shown in U.S. Pat. No. 4,861,988 issued Aug. 29, 1989 to Cornell Research Foundation, Inc. As shown, the ion source **12** includes a needle **14** which receives a liquid sample from a source such as a liquid chromatograph **16**. A tube **18** encircles the needle **14** and supplies a relatively high velocity atomizing sheath gas (e.g. nitrogen) from source **20**. The needle **14** discharges liquid into an atmospheric pressure chamber **22**. The emerging liquid is atomized and evaporated by the sheath gas from source **20**. Charge is applied to the evaporating liquid by an electric field created by the voltage difference between a voltage source **24** applied to needle **14**, and the chamber **22** which is grounded. This produces ions.

The ions so produced pass in a stream through an orifice **26** in end plate **28** into a gas curtain chamber **30** in which nitrogen or other inert gas is injected, as described in the above mentioned U.S. Pat. No. 4,861,988. The ion stream then passes through another orifice **32** into another chamber **34** where some of the gas present is removed by pump **36**.

The stream of ions, together with some gas from chamber **34**, then passes through orifice **38** in plate **40** into a chamber **42** in which are located four rods **44** arranged in the configuration of a standard quadrupole mass spectrometer. The rods **44**, as will be described, preferably have only RF applied to them, without DC. The stream of ions, indicated at **46**, passes through rods **44**.

The chamber **42** is connected to another pump **48**, so that the rods **44** serve, as described in U.S. Pat. No. 4,963,736 issued Oct. 16, 1990 to MDS Health Group Limited, to separate most of the gas entering chamber **42** from the ion stream **46**.

The ion stream **46** then passes through a interchamber orifice **50** in end plate **52** into another chamber **54**. In chamber **54** the ions pass through a conventional ion lens **56** and then into a conventional ion trap **58** having a ring electrode **60** and end electrodes **62, 64**. Ions enter the trap through an opening in the first end electrode **62**. The ions, when ejected from the trap, leave through an opening in the second end electrode **64** and are then detected by detector **66**.

The ion source **12** normally produces a relatively intense stream of ions. Typically it may produce 6×10^8 ions per second through orifice **38**. The ion trap **58**, however, can store only a limited number of ions. A calculation of the maximum number of ions that can be stored in the trap is as follows.

The ions are stored in an effective potential given by the known equation: