1

3,502,863 ELECTRON BOMBARDMENT TYPE ION SOURCE WITH PERMANENT MAGNET FOCUSING MEANS THEREIN

Hiroshi Tsuyama, Kodaira-shi, Hiroshi Hirose, Katuta-shi, and Hirokazu Kimura, Koganei-shi, Japan, assignors to Hitachi, Ltd., Tokyo, Japan, a corporation of Japan


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4 Claims

1

ABSTRACT OF THE DISCLOSURE

An ion source of electron bombardment type having permanent magnets fitted in one portion of the ionization chamber to increase the density of the electron beam, removing the large solenoid coil used in the prior art. The influence of the magnetic field on the orbit of ions is eliminated, increasing the ion yield without decreasing the resolving power. Various attachments such as a gas introducing pipe, a gas exhausting pipe and the direct introduction system can be attached to the circumference of the evacuated tube so that the pressure of a sample gas in the ionization chamber is raised making the ion intensity 10 to 100 times as large as that of the prior art.

The present invention relates to some improvements in an ion source of the electron bombardment type widely used in various mass spectrometers and their applied apparatus, and the object thereof is to increase the ion intensity without lowering the resolving power.

Another object of the present invention is to increase the linear correlation between the pressure of a sample gas in the ionization chamber and the intensity of generated ions. Still another object of the present invention is to remove the electromagnets disposed around the circumference of a conventional ion source and to make effective use of the space thereof.

Detailed explanation of the present invention will be made hereinafter with reference to the accompanying drawings.

FIG. 1 is a rough longitudinal cross-sectional view showing an example of an ion source of the prior art.

FIG. 2 is a rough longitudinal cross-sectional view of an ion source in one embodiment of the present invention.

FIG. 3 is a rough longitudinal cross section of an ion source in another embodiment of the present invention.

In FIG. 1 showing an ion source of the electron bombardment type according to the prior art, reference numerals 11, 12, and 13 designate ion accelerating electrodes, 14 and 15 members defining an ionization chamber, 16 a filament to emit electrons, 17 a gas introducing pipe, 18 an evacuated tube forming a circumference of the ion source, and 19 a solenoid coil to increase the density of the electron beam in the ionization chamber 15. The sample gas is introduced through the gas introducing pipe 17 to the ionization chamber 15 and receives a bombardment from the electron beam generated between the filament 16 and the electrode 13. Thus an ion beam is generated in the direction as indicated by the arrows. The magnetic field due to the solenoid coil 19 provided outside the evacuated tube 18 gives a spiral motion to the electrons so as to raise the density of the electron beam in the ionization chamber 15 and thereby to increase the ion yield of the sample gas.

However, the conventional ion source described above has various defects. Firstly, since the circumference of the ion source is surrounded by the solenoid coil 19, it is impossible to fit effective attachments in this portion of the apparatus. Secondly, because of the considerable distance between the electron beam and the solenoid coil 19 a large coil is necessary in order to increase the magnetic flux density in the portion where the electron beam passes. Thirdly, if the magnetic field due to the solenoid coil 19 is too strong, the magnetic field affects the ion beam and lowers the resolving power. Fourthly, the sample gas, passing in the vicinity of the solenoid coil 19, receives a thermal decomposition specifically if the sample gas is an organic compound. Fifthly, if the density of the sample gas is increased in order to obtain a high ion intensity, the vacuum of the analyzer tube through which the ion beam passes deteriorates, which also makes the resolving power worse.

The present invention is characterized by the fact that in the ionization chamber comprising permanent magnets in one portion thereof a gas introducing pipe to introduce a sample gas into the ionization chamber from a direction perpendicular to the electron beam and a gas exhausting pipe to drive the sample gas out of the ionization chamber are provided.

Now, explanation will be made with reference to FIG. 2, in which 20 designates the permanent magnets fitted in one portion of the ionization chamber, 21 the gas introducing pipe, 22 the gas exhausting pipe, and 23 a variable slit. In advance, the evacuated tube 18 is provided with a high vacuum by a vacuum system (not shown) connected thereto. The sample gas is introduced from a sample reservoir (not shown) through the pipe 21 provided outside the evacuated tube 18 to the ionization chamber 15, and ions liberated by the thermal electron beam emitted from the filament 16. The permanent magnets 20 fitted in the ionization chamber give a spiral motion to the thermal electrons and increase the density of the electron beam in the ionization chamber 15. An excessive introduction of the sample gas into the ionization chamber in order to increase the amount of ion yield results in an increase in the probability of collision between neutral molecules and ions, which lowers the resolving power and causes an abnormal peak due to the ion-molecule reaction. The gas exhausting pipe 22 is provided for the purpose of driving the un-ionized gas out of the ionization chamber.

Specific numerical values for the embodiment are for example, as follows. The outer diameter of the evacuated tube 18 is 60 mm. φ. Dimensions of the ionization chamber are 40 mm. φ. 30 mm. φ., and 15 mm. The inner diameter of the gas introducing pipe 21 is 5 to 6 mm. φ. Dimensions of the permanent magnets are 15 mm. φ., 5 mm. φ., and 5 mm. The magnetic field due to the permanent magnets is preferably strong. Magnets with an intensity of magnetic field of more than 1,000 gauss are used. It should be noted that in the case of the conventional ion source having a solenoid coil 19 around the circumference of the evacuated tube if a magnetic field of 1,000 gauss is to be applied to the electron beam, the dimensions of the solenoid coil become of the order of 200 mm. φ, 60 mm. φ., and 100 mm. The permanent magnets are disposed as shown in FIG. 2, i.e., two ring-shaped magnets are placed opposite to each other in the upper and lower end portions of the ionization chamber.

Another embodiment of the present invention is shown in FIG. 3, in which 23 designates permanent magnets, 24 and 25 disks of magnetic substance having a hole in the center portion thereof to pass the electron beam, and other reference numerals designate like parts as shown in FIG. 2. According to this embodiment, the ionization chamber is formed by permanent magnets 23 and disks 24 and 25. The distance between the two disks in the portion where the sample gas receives a bombardment from the electron beam is narrowed so as to apply a strong and
uniform magnetic field to this portion. The ion source constructed in this way is found to reduce the mass discrimination effect and to make the energy of the generated ions uniform.

As evident from the foregoing description, the circumference of the ion source according to the present invention is free from the restricting presence of a solenoid coil such as provided around the prior art device so that the gas introducing pipe can be attached from the circumference of the ion source. In addition, it is possible to fit various attachments such as a variable slit and the direct introduction system in this portion. The permanent magnets, disposed in the very neighborhood of the electron beam, provide a magnetic field sufficiently strong to converge the electron beam but not so strong as to affect the orbit or ions. Thus the ion yield can be increased without sacrificing the resolving power. Since the sample gas can be introduced into the ionization chamber without any contact with the filament, it hardly causes thermal decomposition. Further, no matter how much sample gas is introduced, the un-ionized gas being driven out directly through the exhausting pipe, neutral molecules cause no disturbance to the ions. Therefore, an improvement in the resolving power is obtained.

Consequently, (1) the linear correlation between the pressure of the sample gas in the ionization chamber and the intensity of the generated ions increases. (2) The mass discrimination effect is substantially reduced. (3) The ion intensity can be made about 10 to 100 times as large as that of the conventional Nier type ion source.

As has been made clear in the foregoing description, an ion source according to the present invention has many advantages over that of prior art, and is very effective if it is used as an ion source for a mass spectrometer, an isotope separator, and other similar apparatus.

What is claimed is:

1. An ion source comprising an ionization chamber including therein at least one permanent magnet disposed completely outside of said ionization chamber, an inlet pipe for introducing a sample gas in a direction perpendicular to said electron beam into said ionization chamber, and an exhaust pipe for exhausting said sample gas from said ionization chamber.

2. An ion source comprising a metal cylinder defining an ionization chamber, at least one permanent magnet with the lines of force thereof generally oriented in the same direction as the axis of said metal cylinder disposed inside said metal cylinder and fixed to end portions of said cylinder, a pair of ferromagnetic plates fixed to both end surfaces, respectively, of said cylinder, each of said ferromagnetic plates having an opening coaxial with said cylinder, an inlet pipe disposed transversely to said cylinder for introducing a sample gas into said ionization chamber, an exhaust pipe disposed transversely to said cylinder on the opposite side to said inlet pipe for exhausting said sample gas from said ionization chamber, an electron gun located outside of said ionization chamber for directing an electron beam to said ionization chamber along the axis thereof, and electrode means for drawing out ions produced in said ionization chamber therefrom.

3. An ion source according to claim 2 in which said metal cylinder and said permanent magnet substantially forms an integral permanent magnet.

4. An ion source according to claim 2 in which the distance between said ferromagnetic plates is smaller at their central portions than at their peripheral portions.

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RALPH G. NILSON, Primary Examiner
A. L. BIRCH, Assistant Examiner
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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,502,863
Hitoshi Tsuyama et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading to the printed specification, after line 9 insert -- Claims priority, application Japan, Aug. 26, 1966, 80892 --.

Signed and sealed this 8th day of December 1970.

(SEAL)
Attest:
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