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MASS SPECTROMETER WITH A PLURALITY OF IONIZATION PROBES

BRIEF DESCRIPTION OF THE INVENTION

This invention relates generally to mass spectrometers, and more particularly to a mass spectrometer having a plurality of ionization probes.

BACKGROUND OF THE INVENTION

Atmospheric pressure ionization (API) sources including electrospray (ES) and atmospheric pressure chemical ionization (APCI) sources which are interfaced with a mass spectrometer have typically operated with a single sample probe. U.S. Pat. No. 5,668,370 describes a mass spectrometer with a plurality of API sources. There is described an API source which includes an ES and an APCI probe which can be selectively brought opposite the input aperture of a mass spectrometer. A relatively complex mechanical arrangement is required to bring the probes opposite the input aperture.

International Publication No. WO 99/13492 describes an API source which includes a plurality of probes directed at a capillary tube which conveys samples into a mass spectrometer. The individual probes are selectively operated to sequentially introduce sample ions into the capillary or they can be simultaneously operated to provide sample ion mixtures to the capillary tube. The fact that the sample applied to the probes is selectively turned on and off may result in clogging of the sample probe.

There is a need for a sample multiprobe API source in which the sources are continuously operated and the ionized sample reaching the coupling orifice is controlled or switched to arrive from selected sources.

OBJECTS AND SUMMARY OF THE INVENTION

It is a general object of the present invention to provide a multiprobe API source in which the sources are selectively coupled to the mass spectrometer inlet aperture or capillary.

It is another object of the present invention to provide a multiprobe API source in which the individual probes are coupled to the inlet aperture or capillary via gas passages in which the passage of ions can be selectively blocked to thereby selectively connect the probes to the inlet aperture or capillary.

The foregoing and other objects of the invention are achieved by a mass spectrometer in which a plurality of API source probes are coupled through an inlet aperture or capillary to the low pressure region of the mass spectrometer by individual conduits which include means for selectively blocking the flow of ions from the associated probe whereby ions from selected probes enter the aperture or capillary.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more clearly understood from the following detailed description when read in conjunction with the accompanying drawings in which:

FIG. 1 shows an API probe coupled to a mass spectrometer via a capillary tube in accordance with the prior art.

FIG. 2 shows multiple API probes coupled to a mass spectrometer through nozzles which communicate with the capillary tube via passages formed in a coupler.

FIG. 3 is an enlarged view of the coupler of FIG. 2.

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FIG. 4 is a sectional view of the nozzle assembly which communicates with the coupler passages.

FIG. 5 shows a coupler configured to sample positive/negative ions generated from a single sample source.

FIGS. 6A-6D are mass spectrograms of four different samples applied to individual probes with sequential coupling to the different probes.

FIGS. 7A and 7B are mass spectrograms of the same sample applied to two probes operated for negative and positive ionization.

DESCRIPTION OF PREFERRED EMBODIMENT(S)

Referring to FIG. 1, a prior art mass spectrometer with an atmospheric pressure ionization probe **11** is illustrated coupled to a mass analyzer **12** by an ion transmission assembly. Although a quadrupole mass analyzer **12** is illustrated, it will be apparent to those skilled in the art that the mass analyzer may include, and is not limited to, time of flight (TOF), quadrupole, Fourier transform (FTMS), ion trap, magnetic sector or hybrid mass analyzers. The atmospheric pressure ion source (API) may comprise an electrospray ion source (ES) or atmospheric pressure chemical ionization source (APCI). In any event, the source includes an ion probe **11** which forms an ion spray **13**. The ionization mechanism involves the desorption at atmospheric pressure of ions from the fine electrically-charged particles formed by the ES or APCI probe.

The sample liquid is delivered to the API probe by, but is not limited to, liquid chromatography pumps, syringe pumps, gravity-feed vessels, pressurized vessels and/or aspiration-feed vessels. Samples may also be introduced using auto-injectors, separation systems such as liquid chromatography or capillary electrophoresis, capillary electrophoresis chromatography and/or manual injection valves connected to the API probe.

The ion transmission assembly includes successive chambers **16**, **17** and **18**, maintained at successively lower pressures with the mass analyzer **12** in the lowest pressure chamber. The first chamber **16** communicates with the atmospheric pressure ionization chamber **21** via a capillary tube **22**. Due to the potential at the end of the capillary tube, ions are caused to travel to the capillary tube where the difference in pressure between the chambers **16** and **21** cause ions and gases to enter the orifice **23** of the capillary tube and flow through the capillary passage into the chamber **16**. The other end of the capillary is opposite a skimmer **31** which separates the chamber **16** from the chamber **17** which houses an ion guiding octopole lens assembly **32**. The skimmer includes a central orifice or aperture **33** which may be aligned with the axis of the bore of the capillary or the capillary bore may be slightly off-axis to reduce neutral noise as described in U.S. Pat. No. Re 35,413. A tube lens **36**, as described in U.S. Pat. No. 5,157,266 cooperates with the end of the capillary to force ions into the center of the expanding ion flow which leaves the capillary and travels toward the skimmer **31**. The octopole lens assembly **32** is followed by ion optics which may comprise a second skimmer **34** and lens **35** which direct ions into the analyzing chamber **18** and into a suitable mass analyzer **12**. The combination of capillary tube **22**, skimmer **31**, lens **32**, skimmer **34** and lens **35** form the ion transmission assembly.

With only one API probe, operation of the mass spectrometer is essentially limited to use with a single sample source or if samples from multiple sources are to be analyzed the sample sources must be selectively coupled to the