

coordinates K_0 . From these calibrated spectra, the values K_0 for the mobilities of the individual ion species and the mobility resolution $R_{mob} = K_0 / \Delta K_0$ of the method can be determined.

For comparisons of measured mobilities with computed mobilities for different conformations of one ion species, it is advantageous to use monoatomic helium as the drift gas because the calculations become simpler. The helium can be used as the curtain gas in an electrospray ion source, passing together with ions through an inlet capillary and into the vacuum system, where the differential evacuation forms it into a jet of gas through the ion guides.

If no such comparison of measured and computed mobility values is planned, nitrogen, clean air or other gases can be used as the curtain gas in the electrospray ion source and for the formation of the jet of gas. For calibrations, in particular, it must be remembered that nitrogen and other gases produce mobility values which are different to those for helium. Another advantageous gas for mobility measurements is argon.

The gas, from which ultimately the gas jet according to the invention is formed, is in most cases added in the electrospray ion source as curtain gas. It accepts the ions and guides them through the inlet capillary into the first stage of the vacuum system. The curtain gas is usually heated to around 200 to 300 degrees Celsius in order to contribute to the desolvation of the ions in the capillary; the gas is greatly cooled in the inlet capillary itself, and particularly in the transitions of the differential pumping stages. It has also been elucidated, however, that the curtain gas can be greatly cooled, for example down to the temperature of liquid nitrogen, before being introduced into the inlet capillary. Cooled curtain gas can contribute to an increase in the mobility resolution of the method according to the invention. The temperature of the curtain gas can also be used to investigate temperature-dependent conformational changes of the ions as a result of changes to the folding, however.

The gases which form the gas jet by emerging from an aperture into the surrounding vacuum can also be added later, at a different location along the path of the ions from the ion source to the ion detector. Some mass spectrometers already have such gas feeds, which are used to fill collision cells for the fragmentation of ions. These collision cells generally take the form of ion guides, and can therefore be used according to the invention for mobility investigations.

For ion mobility measurements in long drift regions, a pressure range of a few hectopascals is usually selected. The acquisition times for a mobility spectrum then amount to a few hundred microseconds. However, according to the equation given above for the part of the mobility resolution determined by the diffusion, the mobility resolution does not depend at all on the pressure. One could therefore apply lower pressures without any disadvantage. But at lower pressures, the drift velocity is higher, which makes the acquisition time for a mobility spectrum so short that only very fast and expensive transient recorders can be used to measure the ion currents.

These considerations do not apply to mobility measurements with methods according to this invention. The mobility resolution seems rather to increase at lower pressures, possibly because the velocity of the adiabatically cooled gas jet is more homogeneous; or even as a result of the formation of a gas jet with the speed of sound. At the end of the second ion funnel (8) from FIG. 1, there is a pressure of between a few pascals and a few tens of pascals only. Methods according to the invention can therefore preferably be carried out at pressures below a few tens of pascals.

The advantage of the methods and instruments according to the invention is the combination of the relatively high mobility resolution and compact size of the necessary devices. A further advantage is that the necessary devices can easily be incorporated into a mass spectrometer. A number of mass spectrometers even already have the necessary devices in a readily usable form.

Persons skilled in the art can easily use this invention as the starting point to develop further application methods and further embodiments. These application methods and embodiments shall be included here in this patent protection application.

What is claimed is:

1. A method for sorting ions into a first group of ions that are pushed over an electric field barrier by a flow of a gas and a second group of ions that are held back by the electric field barrier, comprising:

(a) forming the flow of the gas as a jet by adiabatic expansion of the gas through a nozzle.

2. The method of claim 1, wherein step (a) comprises adiabatically expanding the gas through a Laval nozzle.

3. The method of claim 1, wherein step (a) comprises locating the nozzle in a wall between two chambers of a differential pumping system.

4. The method of claim 1, further comprising (b) measuring the first group of ions without mass separation by an ion detector.

5. The method of claim 1, further comprising (b) measuring the first group of ions with mass separation by a mass analyzer.

6. A method for sorting ions, comprising:

(a) entraining the ions in a flow of gas;

(b) forming the flow of the gas into a jet by adiabatic expansion of the gas through a nozzle; and

(c) placing an electric field barrier downstream in the flow of gas from the nozzle, the electric field barrier having a height so that the ions are sorted into a first group of ions that are pushed over an electric field barrier by the flow of a gas and a second group of ions that are held back by the electric field barrier.

7. The method of claim 6, wherein step (c) comprises generating the electric field barrier by DC potentials or RF pseudopotentials at one or more electrodes.

8. The method of claim 6, wherein the nozzle has an exit from which the jet issues and step (c) comprises locating the electric field barrier adjacent the nozzle exit.

9. The method of claim 6, wherein the nozzle has an exit from which the jet issues and step (c) comprises locating the electric field barrier at a predetermined distance from the nozzle exit and placing an ion guide around the jet between the nozzle exit and the electric field barrier so that ions are contained in, and redirected into the gas jet.

10. The method of claim 9, wherein step (c) comprises forming the ion guide as one of an RF multipole rod system, an RF ion funnel, and a system of parallel diaphragms with apertures, alternately connected to one of DC voltages of alternating polarity and two phases of an RF voltage.

11. The method of claim 10, wherein step (c) comprises forming the RF multipole rod system with sufficiently thin pole rods, and fitting the apertures of the diaphragms with skimmers, so that expanding gas outside the jet can escape without substantial hindrance.

12. The method of claim 10, wherein the electric field barrier height is variable and step (c) comprises varying at least one of the magnitude and frequency of the RF voltage at the ion guide as the height of the electric field barrier is varied.

13. The method of claim 9, further comprising: