

diaphragm (9) by several diaphragms, whose shapes and voltages allow the generation of a field barrier with the desired shape.

**[0066]** The reason for the surprisingly high mobility resolutions has not yet been researched in detail. There is some degree of certainty that the shape of the field barrier, the low temperature of the adiabatically cooled gas jet, and the homogeneous velocity of the molecules in the relatively small region of the potential barrier play a role. The central region of the gas jet does not form a flow with a parabolic velocity profile in the ion guide; instead, an equal mean velocity of all molecules across the gas jet prevails in the vicinity of the potential barrier; and this velocity has a very narrow velocity distribution. The narrow spread of the velocities is the result of the adiabatic cooling of the gas during its expansion. The large number of collisions which the ions undergo with gas molecules of almost identical velocity means that such a gas jet causes a relatively equal pressure on all ions with the same collision cross-section. If the height of the field barrier is changed, and if the field barrier has the same height everywhere radially (the shape of a mountain ridge), the change will become effective for all ions of the same mobility simultaneously, regardless of how far an ion is from the axis of the central flow region. This causes all ions of the same collision cross-section from a small region of the ion beam to be pushed relatively synchronously up the positive slope of the field in front of the potential saddle and over the field maximum. This results in a high mobility resolution.

**[0067]** A further reason for the high mobility resolution is the almost complete absence of diffusion broadening of the ion signals. Any diffusion before the barrier is reached has no effect, at least for the first method. For the second method, the brief time to cross the field barrier has the same effect. After crossing the barrier, when the ions are separated according to their mobility, diffusion may have a detrimental effect. The ions should therefore be brought to the ion detector or mass analyzer as quickly as possible to keep the diffusion small. On the way to the ion detector or mass spectrometer, the temperature of the adiabatically cooled gas jet is very low, however, which greatly reduces the diffusion in a favorable way.

**[0068]** The shape of the gas jet and speed of its molecules resulting from the free expansion of the gas from the aperture depend on the shape of the nozzle. In the publication by J. S. Page et al., a gas jet at the speed of sound is postulated for a simple cylindrical hole in a thin wall. If a sufficiently large pressure difference exists between the two sides of the aperture, a Laval nozzle can generate a supersonic jet traversing the vacuum chamber. This supersonic jet can then push the ions over the potential barrier. The formation of a gas jet with the speed of sound, or even a supersonic jet, shall explicitly be included here when free adiabatic expansion of the gas from an aperture into the surrounding vacuum is discussed.

**[0069]** The ion mobility spectra represent the distribution of the ions over different conformational or structural isomers. The structural isomers are usually very stable and therefore they are practically always measured strongly proportional to their concentrations in the sample. Conformational isomers, on the other hand, can transform into other forms at higher temperatures; their distribution in the ion mobility spectrum shows only how their original distribution in the sample was modified by processes in the ion source and in further steps by temperatures of surrounding gases. Such transitions can be avoided by carefully keeping the gas tem-

peratures low; but they can also be deliberately brought about by changing the temperature of the gases surrounding the ions, and be investigated.

**[0070]** In some electrospray ion sources, for example, the temperature of the curtain gas can be varied between  $-70$  and  $+300$  degrees Celsius. A hot curtain gas is used if it is necessary to free the analyte ions from their solvate sheath. But there are many types of analyte molecule whose ions do not form a solvate sheath, or whose solvate sheaths disappear of their own accord in the vacuum. For these ions, the transitions between different conformational isomers can be investigated by careful temperature management. If the ions are produced in a very cold curtain gas, the original folding structure of the analyte molecules will be conserved to a large extent. The curtain gas becomes progressively colder when it is introduced into the vacuum system via the inlet capillary and on its subsequent passage through the mass spectrometer, and therefore cannot effect any changes to the folding structure. If the temperature of the curtain gas in the ion source is now increased either continuously or incrementally, newly appearing conformational isomers can be found by acquiring series of mobility spectra. Careful measurements of the gas temperatures in the ion source allow the heights of the energy barriers between the different conformational isomers to be measured.

**[0071]** If the ion source is operated continuously with cold curtain gas, the curtain gas can also be heated by suitable means at a different location, for example in the first ion funnel, and used for the investigation of conformational transitions. It is also possible to introduce temperature-controlled gas to the mass spectrometer at other locations and to use it for conformational studies.

**[0072]** DC field barriers with different shapes can be generated by individual apertures, and also by combinations of apertures. A known combination of apertures is the so-called "Einzel lens", which consists of three diaphragms with apertures the two outer ones being at the same potential. The height of the potential barrier can be adjusted by a voltage on the center diaphragm. The shape of the field maximum in front of the potential saddle can be readily shaped in Einzel lenses by selecting the spacing between the diaphragm apertures and their diameters.

**[0073]** Instead of a real DC field barrier to generate the field maximum, a barrier of a pseudopotential can be used, which can be generated preferably by an RF voltage at a bipolar grid across the jet; but also RF voltages at an aperture at the end of the ion funnel will generate such a barrier. The field maximum of the pseudopotential barrier sharpens the mobility selection because the maximum of the pseudofield allows not only ions below a mobility threshold, but also those above a mass threshold to pass. Pseudofields exert a pseudoforce on ions which is inversely proportional to their mass. A combination of pseudofields and real fields can also be used.

**[0074]** The ion guides required to canalize the ions to the potential barrier can have very different forms. They can be multipole rod systems, for example, which are operated with RF voltages, like that presented in FIG. 10. They can also be systems of parallel ring diaphragms or ion funnels, in which case radially focusing pseudopotentials can be mixed with DC voltage gradients that drive the ions forward in the axial direction to redirect them into the gas jet. However, the ion guide system can simply be an ion-optical lens system without applying RF voltages. It has long been known that an arrangement of parallel diaphragms with apertures to which