

plary: 1) a circle of 0.43 mm diameter, 2) a non-contiguous "slit" made of 11 circular 0.13-mm holes disposed uniformly along a 4-mm segment, and 3) a similar slit with 0.19 mm holes. The cross-sectional area of apertures 1) and 2) is 0.145 mm<sup>2</sup>, resulting in equal funnel pressure of 2 Torr, and that of aperture 3) is twice greater at 0.29 mm<sup>2</sup>, resulting in proportionately larger pressure of 4 Torr. The rationale for a slit aperture is to maximize overlap with a ribbon-like ion beam exiting the hooked DMS apparatus 100. Funnel 518 focuses and guides broad or divergent ion beams in a pseudopotential well created by a combination of dc and rf voltages applied to electrodes 520. In the instant application, voltages are 187 V to 40 V dc along the funnel 518, 190 V on the aperture 30, and 175 V on jet disrupter 522. The peak rf amplitude is 45 V (at 560 kHz). All listed voltages are for positive ions, and would be reversed for negative ion analyses.

#### EXAMPLE

To test the capability of the invention to enhance transmission of ions filtered by planar FAIMS to following stages, common MS standards were analyzed using a planar FAIMS/TOF MS system. The instrument was configured with or without the FAIMS/MS interface of the invention described above in reference to FIG. 7, including a non-contiguous "slit" aperture made of 11 circular holes 0.19 mm in diameter, all other conditions being equal. This integrated configuration is exemplary of many like systems and is intended to be illustrative, not exclusive. All such systems as will be contemplated by those of skill in the art in view of the disclosure are within the scope of the invention. No limitations are intended.

Experimental. Solutions of reserpine (5 μM and 50 μM) and bradykinin (10 μM) in 50:49:1 methanol:water:acetic acid were used. The DMS unit described hereinabove was operated using a DV voltage of 3.9 kV and a CV scan rate of 5 V/min. Ion signals measured at the MS detector with a hooked DMS and a standard planar DMS for these samples are compared in FIGS. 8a-8c.

Results. The hooked DMS has improved sensitivity for bradykinin (2+) ions (FIG. 8c), but not for reserpine (1+) ions from either solution (FIGS. 8a and 8b). The difference is primarily due to ion focusing in the hooked DMS getting stronger at higher absolute CV values (here ~8 V for bradykinin and ~3 V for reserpine). As is well-known in the art, for peptide ions, higher absolute CVs are strongly correlated with higher charge states. Thus ion focusing in the hooked DMS preferentially raises the intensity of multiply-charged peptides, which may actually be welcome in proteomic analyses where relative suppression of (1+) ions that contain most chemical noise is often sought.

We claim:

1. An apparatus for improved interfacing of at least one differential mobility spectrometry (DMS) analyzer having substantially planar electrodes to other stages, comprising:

at least two curved electrodes with a gap therebetween filled with a gas and operable for receiving ions introduced thereto, carrying a periodic asymmetric waveform and a dc compensation voltage that jointly establish spatially inhomogeneous electric field in said gap, which focuses said ions toward the median of said gap before and/or after said at least one DMS analyzer; and wherein the range of DMS separation parameters selected substantially includes that set by operation of said DMS analyzer such that said ions are focused to said gap median without significant losses, creating a thinner ion beam that is more completely transmitted through aper-

tures of limited size to said other stages and/or more effectively injected into said DMS analyzer.

2. An apparatus of claim 1, operably coupled to an ionization source selected from the group consisting of electrospray (ESI), thermospray, sonic spray, desorption ESI (DESI), matrix assisted laser desorption ionization (MALDI) and atmospheric pressure MALDI (AP-MALDI), surface-enhanced laser desorption ionization, chemical ionization (CI) and atmospheric pressure CI (APCI), photoionization and atmospheric pressure photoionization, laser vaporization or desorption, secondary ion ionization, arc discharge, inductively coupled plasma, coronary or cathode discharge, electron impact, liquid evaporation, liquid clustering, "pick-up", and combinations thereof.

3. An apparatus of claim 1, wherein said DMS analyzer operates on the principles of field asymmetric waveform ion mobility spectrometry (FAIMS).

4. An apparatus of claim 1, wherein said DMS analyzer operates on the principles of higher-order differential ion mobility spectrometry (HODIMS).

5. An apparatus of claim 1, wherein said DMS analyzer operates on the principles of ion-mobility spectrometry with alignment of the dipole direction (IMS-ADD).

6. An apparatus of claim 1, wherein ions are driven through said gap between said curved electrodes by flow of said gas.

7. An apparatus of claim 6, wherein said gas is selected from the group consisting of H<sub>2</sub>, He, N<sub>2</sub>, O<sub>2</sub>, CO<sub>2</sub>, SF<sub>6</sub>, and mixtures thereof.

8. An apparatus of claim 7, wherein said gas is a mixture comprising He at a concentration in the range from about 10% to about 90% by volume.

9. An apparatus of claim 1, wherein ions are driven through said gap between said curved electrodes by a component of electric field directed along said gap.

10. An apparatus of claim 1, wherein one set of said curved electrodes receives ions from at least two different DMS analyzers.

11. An apparatus of claim 1, wherein one set of said curved electrodes delivers ions to at least two different DMS analyzers.

12. An apparatus of claim 1, comprising two sets of said curved electrodes, wherein one set delivers ions to said at least one substantially planar DMS analyzer and the other set receives ions from that analyzer.

13. An apparatus of claim 12, wherein the number of said DMS analyzers is two.

14. An apparatus of claim 1, wherein the gap width between said curved electrodes substantially equals the distance between said DMS analyzer electrodes and said waveform applied to said curved electrodes substantially matches that used in said DMS analyzer.

15. An apparatus of claim 1, wherein at least one of said curved electrodes is contiguous with at least one of said DMS analyzer electrodes.

16. An apparatus of claim 15, wherein one of said curved electrodes is contiguous with one of said DMS analyzer electrodes and the other of said curved electrodes is contiguous with the other of said DMS analyzer electrodes, such that the same waveform is loaded simultaneously on said curved electrodes and said DMS analyzer electrodes coupled thereto.

17. An apparatus of claim 1, wherein said curved electrodes are cylindrical segments produced by resection of an angular arc from two coaxial cylinders and positioned such that the cylindrical axis is parallel to the plane of said DMS analyzer and the annular gap median is substantially coincident with