(2.3 mm I.D.) of ion funnel was smaller than that of the 2.6 mm I.D. skimmer of the standard interface, it was evident that a more intense gas jet formed by the multi-capillary inlet compared to the standard inlet aperture for the API 3000, and implying that the effective pressure in the ion funnel is higher than the ~1 Torr indicated above.

[0019] The incoming ion current to the ion funnel from the heated capillary inlet was measured by summing the currents to the ion funnel, the DC lens after ion funnel, the collisional cooling quadrupole ion guide (Q0) and a conductance limit after Q0 (IQ1). The ion funnel transmitted current was measured by measuring the electric current to Q0 and a conductance limit after Q0 (IQ1). (During the current measurements, the down stream components were biased to +20 V.) To determine the transmission efficiency through the analyzing quadrupole (Q1), the ion current was measured before and after Q1. The ion current before Q1 was evaluated by measuring the current on lens IQ1 with down stream elements biased to +60 V. The ion current after Q1 was similarly measured on IQ2. Typical bias potentials are given in Table 1.

TABLE 1

The bias potentials of the ion optical element used for performance evaluation.

Component	Bias (V)
Capillary inlet	+120 to +360
Front ion funnel	+120 to +360
Bottom ion funnel	+28
L0	+24
Q0	+20
IQ1	+12
Stub1	+10
Q1	+15
Stub2	+10
IQ2	0
Q2	−20
IQ3	−40
Stub3	−60
Q3	−80

[0020] The standard ion inlet of the API 3000 mass spectrometry was used for the transmitted current measurements. In experiments with the standard inlet, the electrospray emitter (i.e., ion source) was tilted by 45 degrees, as in the standard operational configuration for the API 3000. In experiments with the heated capillary inlet, the electrospray emitter was evaluated in both 45 degree tilted and conventionally aligned configurations. The ion transmission was similar in both configurations after optimization, but the aligned configuration was adapted in this study with the capillary inlet due to its greater ease of optimization.

[0021] The position of the emitter tip and the nebulizing gas flow rate were adjusted to optimize the ion current after the ion funnel. Dodecyltrimethylammoniumbromide (DDTMA, $C_{15}H_{34}NBr$) in acetonitrile was used to evaluate ion funnel transmission at relatively low m/z. The DDTMA was purchased from Sigma (St. Louis, Mo.) and the acetonitrile was purchased from Aldrich (Milwaukee, Wis.), and were used without further purification. The potential applied to the electrospray emitter was 4500-5500 V The measurement of ion currents after m/z-analysis largely assures that the transmitted ion current from an ESI source arises from analytically useful charged species, and this gives increased confidence in performance evaluation. **FIG. 3** gives the ion currents measured through the ion funnel using the 0.51 mm I.D. seven capillary inlet design (closed circles), the ion current through an inter-quadrupole lens (IQ1, located between Q0 and Q1) (open circles), and the ion current after the analyzing quadrupole (reversed triangles) as functions of ion funnel RF amplitude. The inlet ion current was 5.4±0.2 nA. The results show that the ion transmission through ion funnel increases with increasing RF amplitude to a level where over 60% of the inlet current is transmitted, and then decreases with further RF amplitude increases. That observed transmission trend is typical for an RF ion guide; at first the ion transmission increases with increasing RF amplitude due to the increased pseudo-potential of the trapping field, and is followed at some point by a decrease with further RF amplitude increase due to the unstable trajectories or RF driven fragmentation of lower m/z ions. The results also clearly show that the transmitted ion current at zero RF amplitude is well below that realized at optimal RF amplitudes (i.e. at 60-100 V), demonstrating that the ion transmission through the ion funnel is a result of ion confinement due to the RF electric field. As a result, the ratio of transmitted ion current to the neutral gas transmission is higher than in a conventional (e.g. orifice-skimmer or capillary-skimmer) interface. In the conventional, orifice (or capillary)—DC focusing lens—skimmer interface, the distance between the inlet and the skimmer is few mm and a much larger fraction of the orifice-passed gas can enter to the second chamber through the skimmer.

[0022] It is of particular importance to note that the maximum ion transmission efficiency was similar to that obtained with a single same I.D. capillary inlet, but with a higher ion current. The high transmission efficiency with the multi-capillary—ion funnel interface can be explained by two factors. The multiple capillary design provides droplet desolvation that is similar to that for a single capillary inlet of the same I.D. This is in contrast to the poor transmission efficiency observed for a single capillary of larger I.D. of a given length where the effective heated surface to volume ratio is reduced and desolvation is less efficient. This improved performance may also be attributed to a reduced gas dynamics effect. Instead of a larger expanding gas jet of a single larger I.D. inlet, the down-stream gas dynamics of the multi-capillary inlet will produce a complex pattern of jets that might be expected to interact destructively, and lead to a reduced gas dynamics effect. While the latter is speculative at this point, the data clearly shows a substantial improvement in the analytically useful ion current transmitted through the ion funnel.

[0023] Ion Transmission Comparisons with Standard Interface

[0024] The ion transmission for various multi-capillary configurations was compared with that for the standard interface of the API 3000 as shown in Table 2.

TABLE 2

Sensitivity gain using jet disturber equipped ion funnel for high concentration samples.

	M/z	Enhancement[a] Seven capillary[b]
5-FU	129.0	8.8
500 pg/ul	41.8*	10.7
Minoxidil	210	5.2