SUPPORTING INFORMATION

Liquid Phase Ion Mobility Spectrometry

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Figure S-1

The gating efficiency of Bradbury-Nielsen ion shutter was examined with the LiPIMS shown in this figure. The ion shutter was placed between two lengths of resistive glass tube (Burle Technologies Inc., Lancaster, PA). The second resistive glass tube, located behind the ion shutter, was essentially the drift region of the LiPIMS. A stainless steel Faraday plate was placed after the drift region. The Faraday plate was separated and electrically insulated from the second resistive glass tube by a Macor ceramic ring. The resistive glass tube (4.1 mm inner diameter, 5.4 mm outer diameter and 5 mm in length) had an internal surface resistance of 10 MΩ. The external surface resistance of the resistive glass tube was discontinued. Electrodes were attached to either ends of the resistive glass tube. The Bradbury-Nielsen shutter was constructed from two Macor ceramic rings with 4.56 mm inner diameter, 9.30 mm outer diameter and a thickness of 2.26 mm. Alloy 46 stainless steel wires of 76 μm diameter (California Fine Wire Company, Grover Beach, CA) were wound at 0.64 mm parallel spacing. The shutter wires were sandwiched between the two Macor rings and secured with a ceramic adhesive (Resbond 940, Cotronics Corp., Brooklyn, NY). Alternate wires on the Bradbury-Nielsen shutter were electrically insulated, such that this would create an electrical field, orthogonal to the LiPIMS electric field, when a potential was applied across these alternate wires. The pulsing of the ion shutter was controlled by a Double Pole Single Throw (DPST) two-way switch, constructed by Technical Services of Washington State University. The sample was introduced via a fused silica capillary and ionized by electrodispersion ionization. The instrument was held steady by a poly(dimethylsiloxane) cover, and immersed into a 50 ml-Pyrex beaker filled with the hexane.

Figure S-2

This figure showed the schematic of the liquid phase ion mobility spectrometer with Tyndall ion shutter. The liquid phase ion mobility spectrometer was produced by hollowing out half-cylindrical shape from a Teflon block (A). Slits for conducting electrodes were cut into the Teflon block at 1-mm apart. Stainless steel electrodes (Fotofab, Chicago IL) were inserted into each slit. The ion mobility spectrometer had a 5 mm inner diameter and a length of 20 mm. Aqueous samples were introduced into the IMS tube through a fused silica capillary (B). The EDI voltage was applied to a metal union connected to the fused silica capillary. The electrodes were connected externally in series with 1-M□ resistors. The Tyndall ion shutter consisted of a photo-etched gate electrode, with parallel wires 0.14 mm wide and 0.46 mm spacing, was positioned at the sixth electrode. To close the ion shutter, the voltage of the gate electrode was electrically shorted to the eighth electrode to form a reverse electric field that stopped the ions from migrating forward. To open the shutter, the voltage of the gate electrode was switched back to its normal voltage, in line with the resistor series, allowing ions to migrate forward. The pulsing of the ion shutter was controlled by a Double Pole Single Throw (DPST) two-way switch.

Figure S-3

The electric field of the LiPIMS was 600 V/cm and 1695 V/cm in the examination of gating efficinty of Bradbury-Nielsen ion shutter and Tyndall ion shutter, respectively. This figure showed the percentage of the total ion current stopped by the Bradbury-Nielsennd ion shutter (a) and by the Tyndall Ion shutter (b) in hexane.

The Bradbury-Nielsen shutter was able to stop 90% of the ions at an orthogonal field of 6000 V/cm (10 times the electric field of the LiPIMS) and it was able to stop 95% of the ions at an orthogonal field of 11100V/cm (18.5 times the electric field of the LiPIMS) (Supplementary Figure 4a). These results suggested that an effective Bradbury-Nielsen shutter would require an orthogonal

field of 19000V/cm (32 times the electric field of the LiPIMS). Unfortunately, the occurrence of increased noise level and arcing between the gate wires prevented the use of higher orthogonal fields.

At the maximum reverse field obtainable on the Tyndall shutter of 13690 V/cm, which was 8 times greater than the electric field of the LiPIMS, the Tyndall shutter stopped 95% of the total ion current (Supplementary Figure 4b). This suggested that a reverse field of 14260V/cm, or 8.5 times greater than the forward mobility field, would be sufficient in stopping the ions from migrating further.

Figure S-1. Photograph of a resistive glass-LiPIMS, used for testing the gating efficiency of Bradbury-Nielsen gate in hexane.

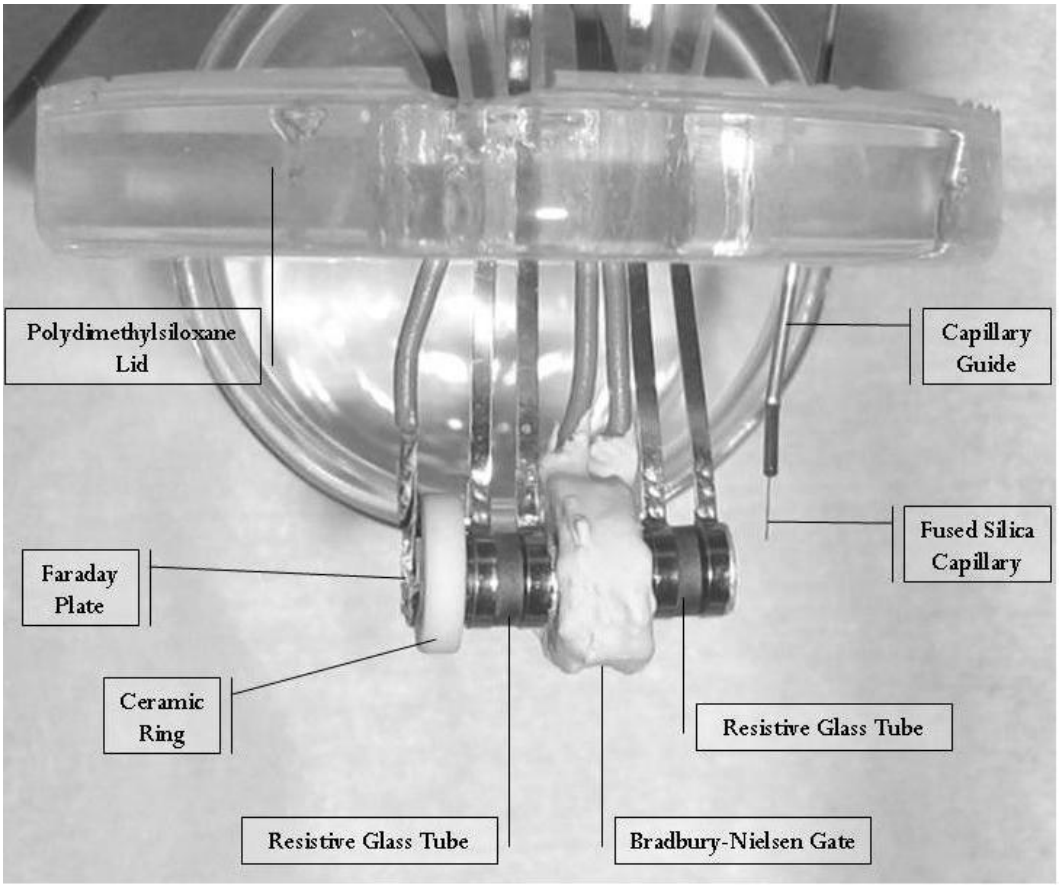


Figure S-2. Schematic of the stacked-ring liquid phase ion mobility spectrometry with electrodispersion ionization, used for studying the gating efficiency of Tyndall ion shutter.

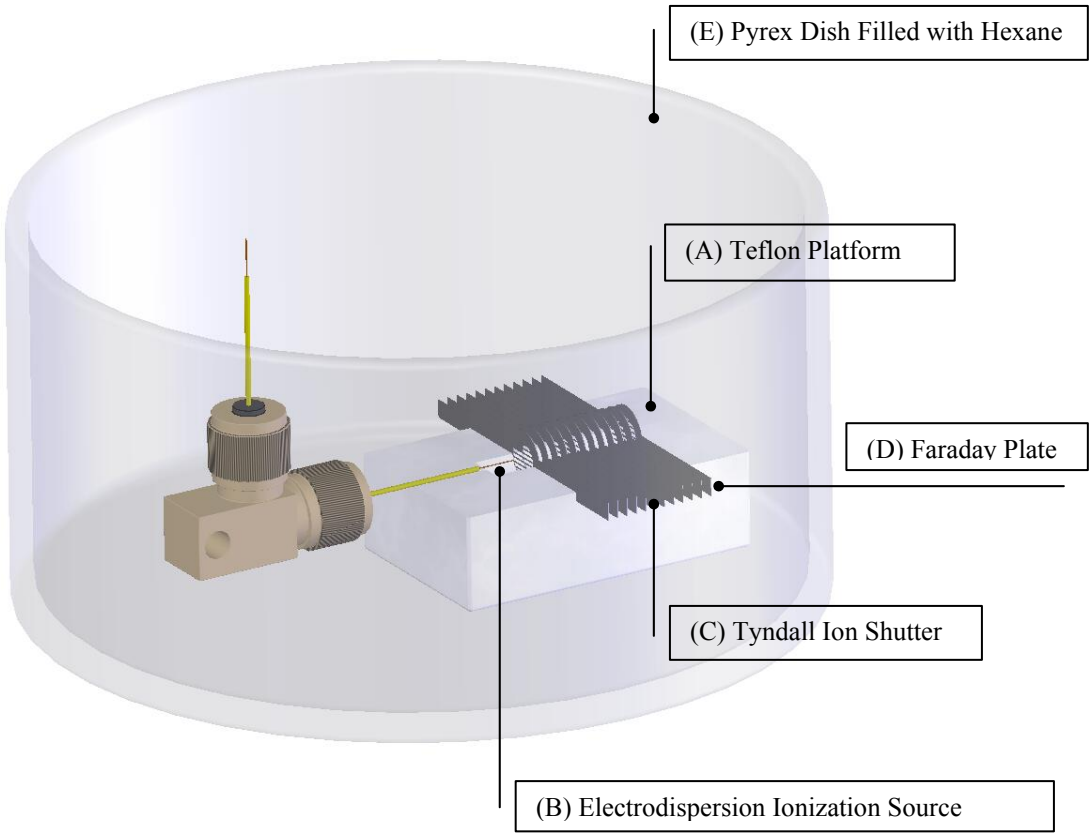
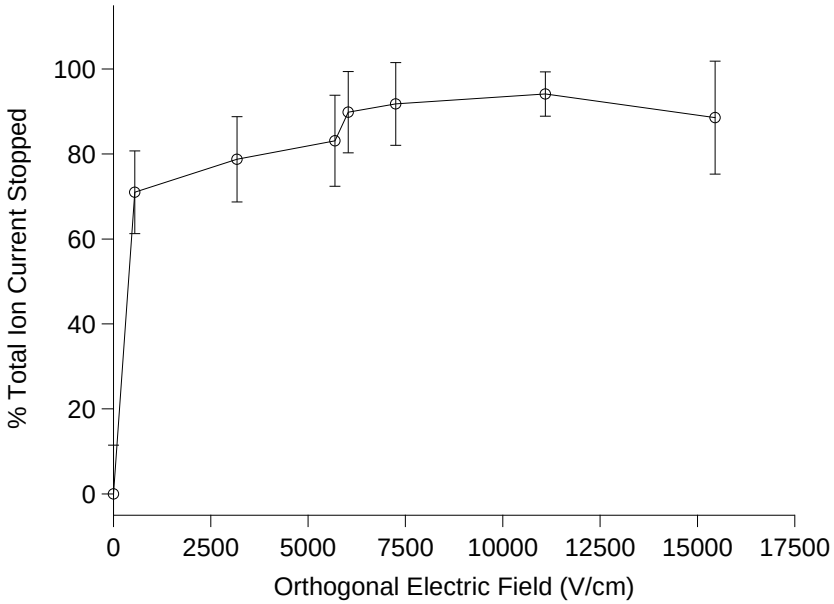


Figure S-3. The effectiveness of (a) Bradbury-Nielsen shutter and (b) Tyndall shutter in stopping ion current in liquid phase ion mobility spectrometry.

(a)



(b)