**Microchip Electrospay Emitters for Stable Cone-Jet Mode Operation in the Nano-Flow Regime**

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**Overview**
- Microfluidics technology enables the processing of trace samples to be integrated with fast, efficient separations on a single device.
- Coupling of microfluidics with electrospray ionization (ESI) promises to provide a powerful platform for proteomics analyses.
- Operation of the ESI source in the cone-jet mode at nL/min flow rates provides uniformly small, highly charged droplets that enable effective ionization for high-sensitivity MS analysis.
- We have developed a simple, robust microchip ESI interface. The cone-jet mode operation, novel auxiliary channel used to supply the electrospray voltage, and the sub-nL post-column dead volume offer promise for coupling with high-resolution microchip separations.

**Methods**

**Device Fabrication**
- 8 µm deep features are patterned in PDMS from an SU8-on-polystyrene (PS) microchip interface for ESI using simple and widely applicable microfabrication procedures.
- The interface uses an auxiliary channel to provide electrical contact for the stable cone-jet electrospray without sample loss or dilution.
- ESI enhancement is achieved by two vertical cuts that cause the interface to taper to a line rather than to a point, and the formation of a small Taylor cone at the channel exit ensures sub-nL post-column dead volumes.

**Emitter Characterization**
- Cone-jet electrospray was demonstrated for up to 90% aqueous solutions and for extended durations.
- Comparable ESI sensitivities were achieved when using both microchip and conventional fused silica ESI capillary emitters, but stable cone-jet mode electrospray could be established over a far broader range of flow rates (from 50 to 500 nL/min) and applied potentials using the microchip emitters. This stability of the microchip emitters should simplify electrospray optimization and make the stable electrospray more resistant to external perturbations.

**Results**

**Cone-Jet Mode Operation**
- The Taylor cone of the microchip emitter decreases in size and the base of the cone decreases at an increasing electric field (Figure 6).
- This flexibility enables the cone angle to be largely preserved.
- With the base diameter of the capillary emitter fixed, the electrospray is destabilized at higher voltages.

**Extended Operation**
- The cone-jet mode operation is stable over a far broader range of flow rates and voltages than the microchip emitter.
- Microchip cone-jet stability ensures robust operation with minimal fine-tuning.

**Simple elastomeric ESI interface for coupling microfluidics with mass spectrometry**

**Conclusions**
- The notable features of the microchip ESI interface presented here include:
  - Straightforward device fabrication, using a single tool and common microfabrication procedures.
  - An electrospray auxiliary channel provides electrical contact for ESI without introducing dead volume or diluting the sample.
  - Decoupling the ESI from the sample channel should enable real-time evaluation with electrical performance and stability.
  - Robust performance at flow rates as low as 50 nL/min.
  - Similar sensitivity and signal stability compared with conventional fused silica capillary emitters.
  - Stable operation in the one-bottle, stable, broad range of flow rates and applied potentials.

- Future work will focus on coupling the interface with integrated microdevices for proteomics analyses, combining sample preparation and separation with ESI-MS.

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**References**