

A Novel Interface for Ion Focusing at Elevated Pressures Based on the Tripole RF Ion Guide.

Alexander S. Misharin, Eugene Moskovets, Chaminda M. Gamage, Vladimir M. Doroshenko and Andrey N. Vilkov
 MassTech, Inc., Columbia, MD

OVERVIEW

- The first experimental demonstration of the RF tripole ion guide.
- Comparison of the ion transmission properties of the tripole and quadrupole ion guides at 1 Torr pressure.

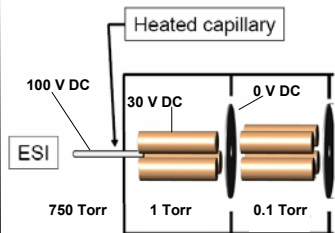
INTRODUCTION

A sensitivity and dynamic range of mass spectrometers with atmospheric ion sources (ESI, APCI, etc) are greatly influenced by losses in the system transmitting ions from atmospheric to low-pressure regions of the mass spectrometer. The ion transmission at pressures of ~ 1 Torr is of special importance since this is the region where significant ion losses take place. At present, only two RF ion guides have demonstrated a reasonable performance at 0.1 - 5 Torr pressure: ion funnels and quadrupole RF guides. We demonstrate for the first time the operational tripole RF ion guide, report the initial results on its performance at elevated pressures and compare its performance to that of the quadrupole ion guide at the same pressure conditions.

METHOD

Instrumentation

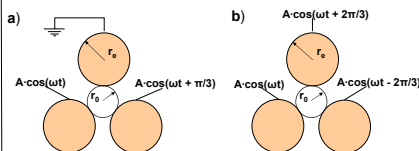
Experiments were conducted on a home-built FT-ICR mass spectrometer utilizing a permanent 1-T magnet described elsewhere [1]. The instrument was equipped with an ESI ion source and an atmospheric interface consisting of the heated capillary (0.5 mm i.d., 150 mm long) the low-pressure end of which is inserted 2 mm inside the tripole (quadrupole) ion guide. The tripole comprises three parallel cylindrical rods, 40 mm in length and 8 mm in diameter, arranged at 2 mm distance from the symmetry axis. Quadrupole was 40 mm long with rod diameter of 6 mm and inscribed field radius of 2.616 mm. The rods of tripole and quadrupole were biased with the same (30V) offset voltage. To feed the tripole, the three RF signals were produced by separate Tektronix AFG 3022 waveform generators and were further amplified by ENI 240L RF power amplifiers.



The tripole ion guide was installed in the low-vacuum region (1-2 Torr, right after the heated capillary) of the home-built FT-ICR mass spectrometer



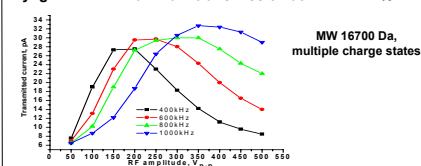
Tripole ion guide.



A cross section of the tripole ion guide. Relative phase shifts of the RF voltages applied across its rods in case when RF voltages were applied across (a) two rods and (b) three rods. $r_0 = 4$ mm; $r_e = 2$ mm.

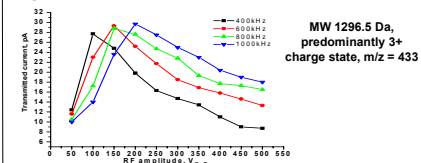
Transmission efficiency:

Tripole in a configuration with one grounded rod
 Myoglobin Maximum transmission at 1MHz: ~22%



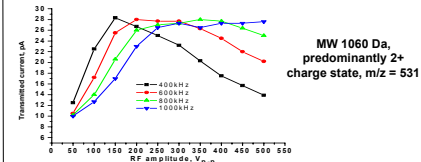
MW 16700 Da, multiple charge states

Angiotensin I Maximum transmission at 1MHz: ~16%



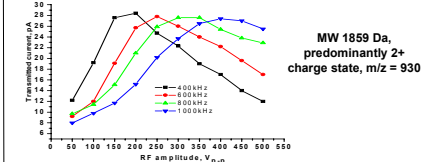
MW 1296.5 Da, predominantly 3+ charge state, m/z = 433

Bradykinin Maximum transmission at 1MHz: ~12%



MW 1060 Da, predominantly 2+ charge state, m/z = 531

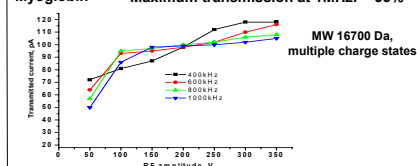
γ-Endorphin Maximum transmission at 1MHz: ~15%



MW 1859 Da, predominantly 2+ charge state, m/z = 930

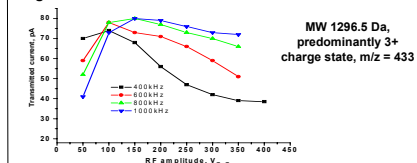
Quadrupole:

Myoglobin Maximum transmission at 1MHz: ~53%



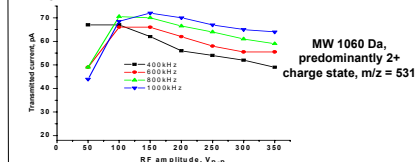
MW 16700 Da, multiple charge states

Angiotensin I Maximum transmission at 1MHz: ~50%



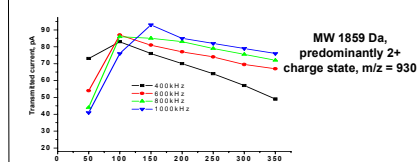
MW 1296.5 Da, predominantly 3+ charge state, m/z = 433

Bradykinin Maximum transmission at 1MHz: ~41%



MW 1060 Da, predominantly 2+ charge state, m/z = 531

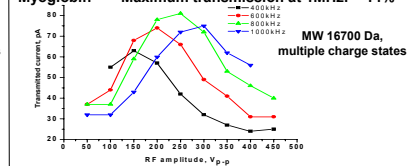
γ-Endorphin Maximum transmission at 1MHz: ~58%



MW 1859 Da, predominantly 2+ charge state, m/z = 930

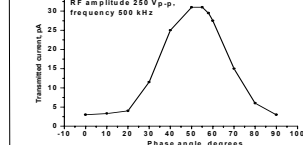
Tripole, three rods

Myoglobin Maximum transmission at 1MHz: ~14%



MW 16700 Da, multiple charge states

Bradykinin RF amplitude 250 V_p-p, frequency 500 kHz



Transmitted current vs phase difference between RF voltages applied across two rods of the tripole in configuration where the third rod is grounded.

CONCLUSIONS

- ✓ The first experimental demonstration of the working tripole ion guide was presented.
- ✓ Transmission properties of the tripole at 1 Torr pressure were evaluated. Transmission efficiency of 10-20% was demonstrated.
- ✓ Transmission properties of the quadrupole at 1 Torr pressure were evaluated. Transmission efficiency of 40-60% was demonstrated.
- ✓ The tripole showed comparable performance when RF was applied to all of its rods and when one of these rods was grounded.

REFERENCES

- A.N. Vilkov, C.M. Gamage et al., in Proceedings of the 54th ASMS Conference on Mass Spectrometry and Allied Topics, Seattle, 2006.
- For numerical simulations of the tripole ion guide please see Salazar G.A., Masujima T., JASMS, Vol. 18, Issue 3, 413-421.