An investigation of mechanisms occurring in paper spray ionization mass spectrometry.


1. Introduction

In the last decade, LC/MS and LC/MS/MS methods are used for quantitative and qualitative analysis for pharmaceutical and clinical applications as well as for biological studies. The challenge in applying MS to tissue analysis is labour intensive and time consuming sample preparation. Recently, Paper spray ionization mass spectrometry (PSI-MS) has been developed as a direct, fast and low-cost sampling and ionization method for pharmaceutical and clinical applications as well as for biological studies. In this study we investigate the mechanism of ion formation in paper spray ionization mass spectrometry.

2. Experimental

All experiments were performed using a Waters Quattro premier triple quadrupole system equipped with a home-made paper spray ionization source. The paper substrate was composed of Whatman # 1 grade filter paper cut into isosceles triangle shapes with approximately dimensions of 10 mm high and 5 mm wide. The paper was supported in front of the MS inlet by a stainless steel clip connected to the instrument ESI High Voltage power supply source. The paper was oriented so that the tip was placed at a 90° and 5 mm from the MS inlet. Both positive and negative ion modes parameters were investigated for the compounds studied (table 1). An image of our hardware design is presented in the figure below;

3. Results

3.1. PSI-MS spectra in positive mode

Fig.1. PSI-MS spectra for progesterone (prog), triiodothyronine (T3) and thyroxine (T4) at 100 μg mL⁻¹

3.2. Range of spray

Fig.2. Images of our paper spray designed at different angle

3.3. Water cluster formation

Fig.5. PSI-MS spectra of back ground for polar and non-polar solvents

4. Discussion

The specific compounds that we tested in our study were Progesterone and the thyroid hormones, thyroxine (T4) and triiodothyronine (T3). Under positive ion, the mass spectra obtained for each hormone showed the protonated molecule [M+H]⁺ at m/z 331, 777.9 and 651.2 for progesterone, T4 and T3, respectively. In negative mode, PSI-MS spectra showed abundant ions [M-H]⁻ at m/z 329, 773.3 and 649.2 for progesterone, T4 and T3, respectively. When comparing both PSI-MS mode, the positive ion mode generated much more intense ions. As a demonstration we monitored thyroid hormones in a salmon tissue. Chromatogram spectra of each hormone in positive modes shown in figure 1.

We observed significant water cluster ions in the background spectra with a variety of solvents. This was true even for nonpolar solvents. We hypothesize that the ability to generate sprays from non polar solvents may be related to naturally high water content in the paper matrix. This is supported by the additional observation that we were unable to generate sprays from non-polar solvents if we dried the paper in an oven or freezed dryer (Fig 5).

5. Conclusion

We believe that the spray is emitted from the paper tip to form a cone shaped distribution of ions.

References


Acknowledgments

The authors would like to thank Western Economic Diversion and BCKDF for funding to purchase instrumentation.

4. Discussion

The specific compounds that we tested in our study were Progesterone and the thyroid hormones, thyroxine (T4) and triiodothyronine (T3). Under positive ion, the mass spectra obtained for each hormone showed the protonated molecule [M+H]⁺ at m/z 331, 777.9 and 651.2 for progesterone, T4 and T3, respectively. In negative mode, PSI-MS spectra showed abundant ions [M-H]⁻ at m/z 329, 773.3 and 649.2 for progesterone, T4 and T3, respectively. When comparing both PSI-MS mode, the positive ion mode generated much more intense ions. As a demonstration we monitored thyroid hormones in a salmon tissue. Chromatogram spectra of each hormone in positive modes shown in figure 1.

The variation in signal intensity with position of the paper relative to the MS inlet is consistent with the spray generating a cone shaped ion distribution. This distribution changes with change the angle (tip position) at constant and various distances.

We observed significant water cluster ions in the background spectra with a variety of solvents. This was true even for non-polar solvents. We hypothesize that the ability to generate sprays from non polar solvents may be related to naturally high water content in the paper matrix. This is supported by the additional observation that we were unable to generate sprays from non-polar solvents if we dried the paper in an oven or freeze dryer (Fig 5).

5. Conclusion

We believe that the spray is emitted from the paper tip to form a cone shaped distribution of ions.

We observed a range of water clusters present in the background spectra from a variety of solvents. From this we speculated that the mechanism for non-polar sprays in Paper Spray depends on the presence of absorbed water species.

Future work will focus on the sample preparation and paper for paper spray ionization measurements.