Corona discharge modification of liquid stream, study by ion mobility spectrometry

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The ion mobility spectrometry (IMS) is low cost and compact analytical technique widely used for explosives and gas warfare agent's detection at the airports and at the places with high concentration of people [1]. The analysis of liquids using the IMS technique is possible in the case of electrospray ionization (ESI) ion source [3]. However, the deployment of ESI to the IMS is associated with difficulties related to evaporation of liquids within IMS [3]. In this work we will demonstrate a new direct liquid sampling technique developed at Comenius University Bratislava. The sampling technique was applied for real-time monitoring of plasma discharge effect on the liquid stream.

1. Introduction

There exist increasing demand for analysis of liquids in various fields of science and applications. The forensic and security applications require monitoring of liquids in order to secure safety of the citizens. The analysis of liquid samples in medical and biochemical applications play important role in understanding and protection of human health. On other hand the wastewater monitoring is important for industrial and environmental applications.

The appropriate technique for liquid sampling by IMS should be chosen on the basis of parameters such as the dimensions, the time consumption and the sensitivity. We present new liquid sampling technique for IMS. The technique is based on direct liquid sampling, where the liquid vapours are directly injected into the reaction region of IMS. The technique was successfully tested for detection of explosives for different liquid solutions and for the analysis of amino acids and dipeptides.

In this work we will present the possibility of IMS equipped by new liquid sampling unit (Direct Liquid Sampling - DLS) for direct and real time analysis of the liquids. We apply this DLS unit to investigate the plasma discharge effect on the liquid stream. We will demonstrate the modification of the aspartame dipeptide by the corona discharge applied across the liquid stream.

2. Experiment

The IMS equipped with corona discharge (CD) ionization source used in this work was developed at Department of Experimental Physics, Comenius University [4]. The CD is point to plain geometry, with 50 μm tungsten wire as point electrode, the discharge gas is 3 mm. The CD is operated in air in both polarities, with discharge currents of ~10 μA and discharge voltages 2.5-3.0 kV. The instruments contain the sample inlet capillary which could be heated to 445 K. The instrument can operate in both polarities. The liquid sampler was placed directly against the capillary inlet for analysis by IMS instrument as we can see in the Figure 1.

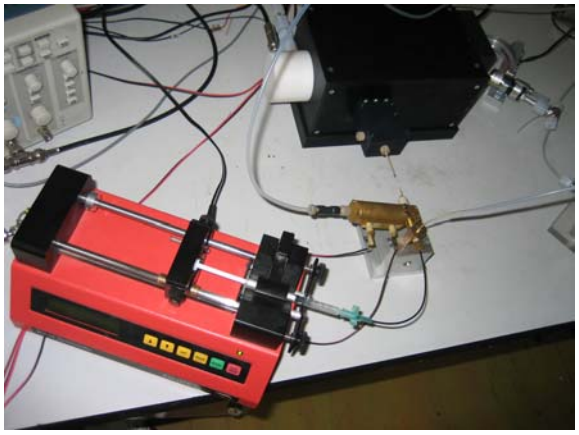

Figure 1. The photograph of direct liquid sampling for IMS

In comparison to the electrospray ionization (ESI) the present direct liquid sampling method does not require any specific solvents for sample introduction. Due to this advantage the liquid

samples can be directly analysed without any preparation. Using this technique we have successfully sampled amino acids and dipeptides directly from water and methanol.
The main difference to the ESI ionisation is, that in contrast to ESI present liquid sampling method was not used for ionisation. In present technique the ionisation is carried out by the chemical ionisation using the ions generated in CD and their ion-molecule reactions with analytes.
An additional advantage of the present sampling technique is the possibility of real time study of the products of discharge treatment of liquids. The Figure 2 demonstrates such an application. The atmospheric pressure discharge was in this case applied on aerosol/vapour stream generated by liquid sampling source.

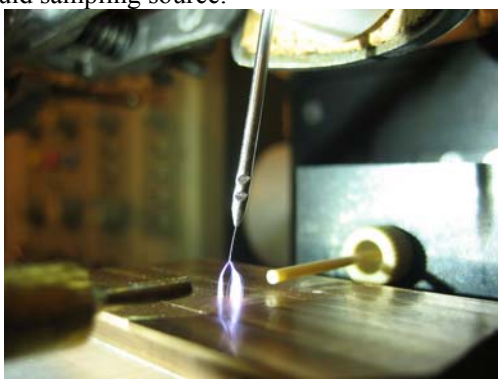

Figure 2. The discharge applied on aerosol jet used for liquid stream analysis.

3. Results and discussion

We have used the DLS unit to form liquid stream from aspartame dipeptide solvated in water. We have applied CD discharge (point to plain geometry, negative polarity, 3.5-6 kV, 0-60 μA) on aspartame solvated in the water. This compound is a methyl ester of the aspartic acid/phenylalanine dipeptide. We were able to detect the decompositions of the aspartame by the discharge.
The Figure 3 shows the IMS response to aspartame molecules. In this Figure we can see the IMS peak with reduced mobility 1.51 and 1.21 $cm^2s^{-1}V^{-1}$. The peak with reduced mobility 1.21 we assign to aspartame while the peak of reduced mobility 1.51 1.21 $cm^2s^{-1}V^{-1}$ we assigned to phenylalanine formed by the decomposition of aspartame in the discharge. The application of the discharge on the aerosol stream resulted in the decomposition of aspartame as we can see in the Figure 4. In this Figure we see that the variation of the discharge current resulted in the changes in the amplitudes of the characteristic peaks, which we ascribe to the decomposition of aspartame. This first study of the liquid stream treatment by CD and the product analysis by the DLS-IMS is very promising and we plan to continue these study in future.

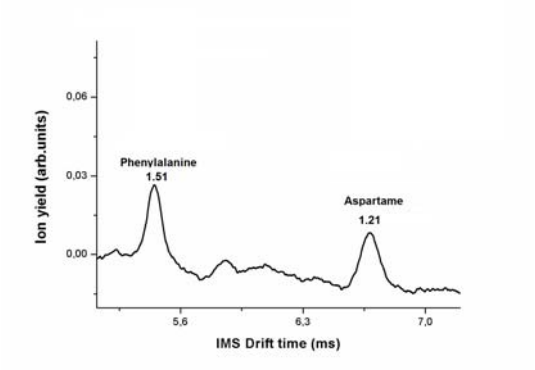

Figure 3. IMS response of aspartame

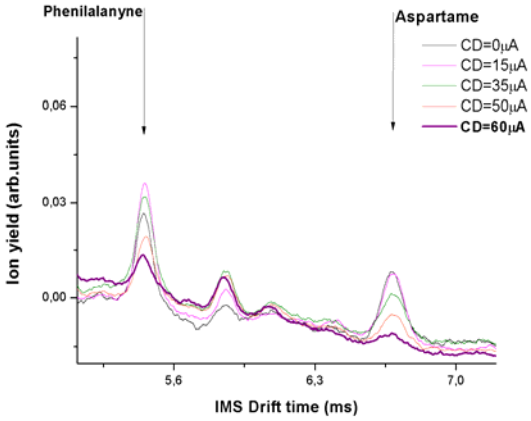

Figure 4. decomposition of apratame and phenylalanine in dependence of CD power

4. Conclusion

In this work we have demonstrated the operation of a new liquid sampling method for the IMS. Usinf the DLS method we were able detect aminoacids and dipeptides directly in water solutions Additionally, we have applied the discharge treatment of the liquid stream and demonstrated that using the DLS-IMS we are able to detect online the decomposition of the amino acids and dipeptides in the water by the discharge. This application was successfully demonstrated on the case of dipeptide aspartame. These first results of application of DLS-IMS method for liquid sampling and detection of the chemicals in the water are very promising and we

plan to continue this research on more systems.

5. Acknowledgement

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6. References

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