THE MICROHOLLOW CATHODE DISCHARGE
A MINIATURIZED PLASMA SOURCE FOR MASS SPECTROMETRY

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Due to the rapid development of small devices there is a strong interest in designing miniaturized plasmas. There are already reports about miniaturized d.c. discharges, inductively or capacitively coupled-µ plasmas. The plasmas have to be powerful and robust, operated at pressures close to atmosphere and their parameters should be of the same order of magnitude like classical plasma sources. Together with the development of small-size discharges, also separation methods were downscaled in order to fulfil the lab on the chip concept. The advantages of miniaturized plasmas in lab-on-the-chip systems would be a further improvement of compactness of the analytical system which allow the application outside of laboratories. Furthermore, parallel and high-throughput measurements can be performed if many systems are used simultaneously.

This paper presents an atmospheric pressure microhollow cathode discharge as an ion source for mass spectrometry. We already reported the use of the microplasma as an emission selective detector with detection limits of halogens in the low ppb range (1).

The microhollow cathode discharge operating at high pressures consists of hollow electrodes with a hole diameter in the range of 50 – 200 µm separated by a submillimeter ceramic isolator. For our investigations 20 µm thick Pt electrodes were separated by a 200 µm Al_2O_3 insulator and the diameter of the hole in the electrodes was 100 µm. A weekly ionized plasma is ignited in the hole of the structure. The microhollow cathode discharge is considered as a normal glow discharge with an increased excitation and ionization efficiency due to the hollow cathode geometry. The plasma parameters at atmospheric pressure were determined through diode laser atomic absorption spectroscopy. The gas temperature is 2000 K in Ar and 1000 K in He and the electron density reaches values of about $6x10^{15}/cm^3$ for the discharge operating in Ar and $2x10^{14}/cm^3$ for operation in He (2). In these conditions the ionization degree of the plasma is in the order of $3x10^{-5}$ in He and 10^{-3} in Ar.

The discharge can be operated in a static regime, when the same pressure is at both sides of the structure or in a jet regime, when a pressure difference is established in the system. By operating with atmospheric pressure at the anode side and pressures lower than 1 mbar at the cathode side, an adiabatic expansion appears. The plasma formed in the hole contains neutral, excited and ionized particles and it expands as a jet in the low pressure region where is cooled down. Such a geometry is suitable for mass spectrometry: the microstructure is acting as ionization source and sampler in the same time. The analyte is mixed with helium and passes through the hole. Elemental ions as well as ionized fragments are detected. Results will be presented concerning the analysis of gas mixtures and volatile compounds by the direct coupling of the gas chromatograph. The detection limits for halogenated hydrocarbons are in the low ppb range.

The microhollow cathode discharge proved to be a promising plasma source to be integrated in an analytical system. The easy way of operation, the low voltage necessary to sustain the plasma and the operation at atmospheric pressure are only some of the advantages. Also, its characteristics like the relatively high gas temperature and electron density as well as a very high power density allow the detection of analytes with relatively good detection limits.

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