Development and fundamental investigation of He micro-plasma detector PLES for gas chromatography

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In analytical chemistry, gas chromatography (GC) has been widely used because of the short measurement time and the low running costs.

In this study, a new type of GC detector using atmospheric pressure He plasma was developed. He has the highest ionization (24.58 eV) and metastable (19.82, 20.62 eV) energies among the elements. This means that He plasma can effectively ionize and excite all elements. In the helium plasma ionization detector, DC-powered He plasma and ring-like electrodes were utilized for ionization of the samples. For an ionization detector, the generation of very stable plasma is important. Therefore, we used next configuration to initiation of DC He microplasma.

Two layers of ceramic of a thickness of 0.15 mm are interleaved with three layers of tungsten of a thickness of 0.1 mm to fabricate the device. The discharge volume is defined by a hole through the center of the sandwiched layers, and the micro-discharge uses a ring cathode created by the hole in the outer tungsten cathode layer. A similar hole in the opposite outer tungsten layer is used as a hollow anode. Device has a hole diameter of 400 mkm. The metallic walls of the discharge volume are used as a wall probe. The anode is grounded and the cathode is connected to the negative pole of the dc voltage source via a resistor of a few hundred kOhm. The desired discharge current is chosen by adjusting the voltage and the resistor values. The device is connected to out of microchromatograph column.

Samples of mixture was previously separated in a microchromatographic column and then detected in a micro-plasma PLES-detector [1].

In addition to the time-dependent detection of the impurities analyzed in helium, impurity detection was performed at the characteristic energies of the Penning electrons.

The energy spectra of the Penning electrons were obtained by measuring the second derivative of the probe VA-characteristic (d^2I/dV_2) with respect to the scanning voltage applied, which, according to the Druyvesteyn's relation, is proportional to the EEDF [1,2]. The Penning electrons' energy spectra were obtained in He as the main gas with small admixtures of Ar, N_2 and O_2.

The recorded energy spectra of Penning electrons at atmospheric He pressures are characterized by the appearance of maxima at characteristic energies corresponding to the energy of the electrons released in Penning reactions involving Ar, N_2, O_2 impurities. Well-expressed maxima in the electron energy spectra are easily obtained as a result of the high number of Penning electrons collected by the large sensor surface.

The effectiveness of the micro-plasma PLES-detector for GC was demonstrated by these results. To further improve the analytical ability, the use of a RF power supply to PLES detector is recommended because high-density plasma can be generated without the electrode overheating.

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REFERENCES

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