MEASUREMENTS OF PLASMA PARAMETERS IN ATMOSPHERIC HELIUM PLASMA DETECTORS FOR GAS CHROMATOGRAPH

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In the field of chemical analysis, the gas chromatograph (GC) has been widely used because of its flexibility, short measurement time and low running cost. Recently, high-sensitive detection is required for further improvement of analytical performance. To realize high sensitivity, excellent detector for GC is needed. Until now, many types of detectors have been developed. Thermal Conductivity Detector (TCD) is the most common detector and it is applicable for almost all samples. But the limit of detection (LOD) of TCD is not good, which is on the order of 100 ppm. Flame ionization detector (FID) is another excellent detector, which utilizes hydrogen flame ionization. So, FID is the best choice for detection of flammable components and it realizes excellent LOD, on the order of 10 ppb. However, FID can not be applicable for detection of inflammable components.

In this study, we developed two new detectors for GC using atmospheric pressure helium plasma. Helium has the highest ionization (24.58 eV) and excitation (19.82, 20.62 eV) energy in all elements. That means helium plasma can effectively ionize and excite all elements. In the helium plasma ionization detector (HPID), DC powered helium plasma is used for ionization of samples. The samples are ionized when it is mixed into the helium afterglow plasma. When 2 ml of 100 ppm hydrogen, nitrogen, oxygen, methane and carbon monoxide are introduced, 30-150 ppb of LOD has been achieved. On the one hand, low frequency plasma – atomic emission detector (LFP-AED) was developed. This detector utilizes LF powered dielectric barrier discharge (DBD) in quartz tube for the excitation of analytes. When 1 ml of 100 ppm fluorocarbons (CH_2Cl_2, CH_2Br_2 and CH_3CH_2I) are introduced, LOD for fluorine, chlorine and bromine are 100 ppb for each. For pursuing further improvement of analytical performance, the fundamental plasma properties were measured using spectroscopic method.

The emission properties, the excitation temperature and the electron number density were measured using spectroscopic method. The excitation temperature based on helium atomic emission lines (He I 447.15, 492.19, 501.57, 587.56 and 667.82 nm) was 2,200 ~ 2,300 K for HPID when the discharge current was changed from 5 mA to 30 mA. For LFP-AED, the excitation temperature was 2,600 K. In addition, electrode configuration and components of the plasma gas were varied to improve analytical performance. The relationship between the plasma parameters and the detection limits will be presented.